THE

PROCEEDINGS AND TRANSACTIONS

OF THE

Nova Scotian Institute of Science

HALIFAX, NOVA SCOTIA

VOLUME XII

1906-1910

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PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1906-1907

ANNUAL BUSINESS MEETING.

Assembly Room, Province Building, Halifax, 12th Nov., 1906.

THE PRESIDENT, F. W. W. DOANE, in the chair.

PRESIDENTIAL ADDRESS: (1) WORK OF THE INSTITUTE; (2) RESEARCH WORK; (3) SANITARY SCIENTIFIC WORK.—By F. W. W. DOANE, C. E., City Engineer, Halifax.

Gentlemen,—A year ago, at the beginning of my twentieth year as a member of the Institute, you elected me to the highest office in your gift, an honor which I appreciate more because I am fully conscious that a better selection might well have been made in order to maintain the standard established by my predecessors.

In opening the forty-fifth session of the Institute by a short review of the events of the past year, it is a pleasure to be able to report that we have met with no losses either through death or resignation.

Papers.—The following papers have been communicated to the Institute during the year:

1. Presidential Address.—By DR. H. S. POOLE.
2. The Flora of MacNab's Island, Halifax.—By CAPTAIN J. H. BARBOUR, M. D., Royal Army Medical Corps.
3. Catalogue of the Birds of Prince Edward Island.—By JOHN MACSWAIN.

4. Mining—Is it a Science?—By W. E. Lishman, M. A., M. Inst. M. E.
5. Additions to the List of Nova Scotia Fungi.—By Dr. A. H. MacKay.
6. Halifak Water Works.—By H. W. Johnston, C. E.
7. The Oil Fields of Eastern Canada.—By Dr. R. W. Ells.
8. The Frost and Drought of 1905.—By F. W. W. Doane.
9. Eels in Water Pipes and Their Migration.—By Watson L. Bishop.
10. Notes on Protective Coloring.—By Frank H. Reid.
11. The Grignard Synthesis: Action of Phenyl Magnesium Bromide on Camphor.—By H. Jermain Creighton.
12. Contribution to the Study of Hydroxylamine.—By G. M. Johnston MacKay, B. A.
13. Water Powers on the Mersey River, N. S.—By W. G. Yorston, C. E.
14. The Damage done to Timber by *Teredo navalis* and *Limnoria lignorum*.—By R. McColl, C. E.
15. Phenological Observations, Canada, 1905.—By Dr. A. H. MacKay.
16. Water-rolled Weed-balls.—By Dr. A. H. MacKay.

Of the thirteen authors who gave the Institute the benefit of their labors and observation, six presented papers for the first time, a fact which in itself is evidence of some progress. We cannot congratulate ourselves, however, that we are in the healthy condition that every member who has the best interest of the Institute at heart could wish. We have been depending too much on the work of the older members, and in consequence of the willingness with which they devote their time and energy to the arduous demands of each session, the enlistment of new workers has been somewhat neglected. While the interest of the older active members has not abated, their work could be lightened by the assistance of the younger members, who, by a little effort, might relieve the strain upon the knowledge and active intellect of those whose wonderful energy in the past has proved equal to the

demand upon them, and who have done so much to place the Nova Scotian Institute of Science among the chief scientific associations of British America.

Membership.—No addition has been made to the list of corresponding members, but four have been proposed and approved as ordinary members or associate members. A number of new members have not yet qualified for membership by paying the annual fee in consequence of defects in our financial system. This matter is receiving the attention of the council, and it is probable that changes will be made which will lead to the adoption of a more satisfactory system and place the finance department on a better business basis.

It should be our aim first to "set our house in order," then to add to our membership as much as possible. We should have on our roll the name of every man in Nova Scotia who has the ability to add to our knowledge, and also all those who, though they may not have the opportunity or the requisite preparatory training to enable them to advance science themselves, are willing to encourage others in their efforts by their interest and their annual fees. There must be many of the latter class in the acquaintance circles of all our members, who might be induced to come in and help us if we make the effort. Indeed, there must be more persons in Nova Scotia devoting some portion of their time to scientific work than those whose names are inscribed on the membership roll of the Institute of Science. Let each member make a list of the names of those whom he considers eligible for membership and submit it to the new council. Let it be the duty of the council, assisted by individual members, to use every endeavor to obtain the allegiance of such persons, and I have no doubt that the result will be very beneficial to the Institute.

Meeting rooms.—The closing meeting of the last session was held in the room of the Mining Society, through the courtesy of its president. While one hesitates to record feelings of envy, it must be admitted that the cozy quarters placed at our service suggested speculations as to the benefits that would result to the Institute if we were able to maintain similar headquarters. If a campaign is

inaugurated for increasing the membership and consequently the revenue of the Institute, the next step should be to consider the advisability and possibility of providing a home for our society. From the first the provincial government gave the use of the only spare room at its disposal, and we are still indebted to the generosity of the government for a place in which to hold our meetings, and also a place wherein to keep our valuable library.

Publication.—We are handicapped by our limited purse and other conditions, so that it would be impossible to expend a larger sum at present on the publication of papers. A great effort should be made, however, to bring this work up to date. We should then consider the advisability of printing before they are read, all papers of general interest or special importance. If an advance-proof of such papers could be sent out some time before the meeting at which they are to be read, it would doubtless result in freer and much more valuable discussion and larger attendance at such meetings. Even under our present system the discussion is often second in value only to the paper itself.

Research work.—The practical value of reseach work is being impressed upon the public, and the business portion of the public is becoming interested more and more in the results of such work.

An address on a strictly scientific subject is not often of particular interest except to those who are engaged in the department of science discussed. The superficial observer who sees the oak but forgets the acorn, is likely to ascribe the great material advances of recent times wholly to scientific knowledge and rare ingenuity, and to consider the great inventors and the great captains of industry as the most important agents in bringing about the modern era. No other agent, however, has been of greater influence in making the mechanical evolution of the latter part of the last century possible than the great scientific investigators whose forceful intellect opened the way to secrets previously hidden from men.

Nature turns a forbidding face to those who pay her court with the hope of gain, and is responsive only to those suitors whose love is for herself alone. It is impossible to know what application

knowledge may have until after it is acquired, and the seeker after purely useful knowledge will fail to acquire any real knowledge whatever. In this fact lies the explanation of the extreme rarity with which the functions of an investigator of the laws of nature and those of the inventor who applies these laws to utilitarian purposes, are united in the same person.

This theme is one of special importance at the present time, because it is customary to ask about every new discovery in science, What is its value? It is only by going backward over the development of applied science that it is possible to realize the fundamental importance of research work. For instance, hardly any of the basic principles of engineering were discovered by men with any intent on practical work. The mathematical methods which are necessary for the engineer are the result of strictly scientific investigation, and the laws of physics and chemistry are being determined by the research work of men who care little whether their discoveries are to find immediate practical application or not. The development of industrial processes often suggests new subjects for investigation, and some of the best research work of to-day is being guided by business corporations, but the men who are so engaged are working in a purely scientific spirit, and leave the practical development of their results to the engineer.

The beginner in research work may be discouraged when he reviews the work of more advanced scientific investigators, in the belief that the greater part of the work has been done. He will soon learn, however, that in the words of the late Cecil Rhodes, "there is so much to be done." For instance, how little we really know of meteorology except a few statistics. How intangible is the air, yet it uproots strong trees firmly anchored in mother earth, tears heavy structures from their foundations and drops them in fragments far from their original location.

There is much to learn and plenty of room for every new worker who has the inclination, the energy and the persistency to wrest from nature her jealously guarded secrets.

Sanitary scientific work.—In that branch of science with which my daily work brings me in intimate connection, prominence

has been given during the year to the extermination of the mosquito, the purification of water by copper sulphate, and the ventilation of sewers and plumbing, and the abolition of the main trap.

The extermination of the mosquito has been accomplished, where it has been undertaken by first a campaign of education, then the expenditure of considerable sums of money in destroying the breeding places by draining and filling up, etc.

The copper sulphate treatment of water has engaged the attention of the world, and it is apparently becoming more and more evident (1) that water infected with algæ can be purified by this means, and (2) that water which has been so purified is quite fit for human consumption, and that no one need fear harmful effects.

Abolition of the drain trap.—The ventilation of sewers and plumbing has been a burning question elsewhere, but the " abolition of the house trap " has become a live question in Halifax, and consequently may be worthy of more than passing notice.

The regulations of the city health board require the installation of a trap at or near the point where the drain leaves the house, and although there has been much diversity of opinion elsewhere regarding the necessity for its use, there had been no question here until the master plumbers asked that the sanitary regulations be amended so that the main trap could be omitted. This trap, known in England as the intercepting trap, is in that country intimately connected with the larger question of the ventilation of sewers and drains, which has been more or less the subject of controversy since the illness of King Edward, when Prince of Wales, in 1872. The intercepting trap was patented by W. P. Buchan, Glasgow, about 1875, and, without any special investigation, was adopted by the local government board and introduced into its model by-laws in 1877. Such official recognition caused its advantages to be taken for granted, and deterred many people from investigating the question for themselves. The controversy resulted in a general concensus of opinion that " sewer gas must be cut off from the house," and the intercepting trap was adopted with that object in view.

Recently many engineers engaged in municipal work have favored the abolition of the trap, and their argument has been

greatly strengthened by experiments made in England and elsewhere to determine whether sewer air is actually dangerous or not. Medical officers of health are more conservative in their views, and are for the most part strongly in favor of the retention of the trap.

It is probably true that there is no local sanitary authority in this province, where sewers, drains and plumbing exist, which has not had to deal, at some period or other, with complaints as to the nuisance caused by the escape of sewer gas, and it may therefore be assumed that the subject is of importance to every section of the community.

It is not advisable or necessary in these remarks to introduce the technical pros and cons that are so often used. Such arguments may be reserved for a technical paper or for the benefit of municipal sanitary authorities. The question which is of special interest to us, and which, too, must be considered to a certain extent unsettled, since it is yet under investigation, is, does sewer air injuriously affect health?

About a year ago the borough council of Hampstead, England, employed two experts, F. W. Andrews, M. D., F. R. C. P., D. P. H., and W. H. Hurtley, D. Sc., to make analyses of sewer air and report on the bacteria suspended therein.

The particular points which the experts set themselves to investigate were: (1) Can it be determined whether the emanations from the sewers are likely to cause disease? (2) What is the substance which gives rise to the disagreeable odors? (3) What is the chemical composition of the sewer air at different levels?

As regards the first point, which is the most important, it is the general, but not altogether unanimous opinion, that sewage bacteria do not exist in sewer air. This opinion has been based upon the results of only a few investigations; and on the other hand it has been abundantly proved that sewer air, escaping direct into houses, has injuriously affected the health of the inmates. This fact has led to the assumption that there must be some subtle chemical action in such cases which has not yet been discovered, and which might possibly also exert its influence in the open air.

The bacteriological examination of sewer air has not received the attention which should have been given to it, and possibly we have in our own ranks members who, by research and investigation, can throw some light on this important question. Within the last few years improved methods for investigating air-borne bacteria, especially *Streptococci,* have been introduced, but they have not yet been applied to sewer air, and when it is borne in mind that *Streptococci* are the most abundant organisms in sewage, that they are amongst the most important of disease-producing bacteria, and that some at least of the diseases to which sewer air is credited with giving rise, are in all probability strepcococcal infections, it is plain that the examination of sewer air for *Streptococci* should prove an important field of investigation.

Improved methods have also been recently introduced whereby the common intestinal bacteria belonging to the *B. coli* group (including the typhoid bacillus) may be much more easily identified and isolated.

The first step taken by Dr. Andrews was to endeavor to find sewage organisms in the sewer air, and he succeeded in finding an organism which was not the true *B. coli communis,* but was identical with a characteristic sewage member of the group, present in the sewage to the number of at least 30,000 per c. c.

The most important experiments, however, were those relating to *Streptococci*; and Dr. Andrews established the fact that the *Streptococci* of the sewer air are very different from those of the fresh air outside the sewers, and in the very point in which they differ from those of the fresh air they tend to approach those of the sewage. The importance of this discovery cannot be over-estimated, and it is fairly obvious that the whole future disposition of sewer ventilation or sewer air treatment may depend upon the facts which further examination in this direction will produce.

The question arises, what effect does this variation in the constitution of *Streptococci* have upon the human constitution? Both Dr. Andrews and Dr. Hurtley remained in the sewers for long periods and it is not recorded that they suffered at all; in fact, Dr. Hurtley specifically states that he did not experience the slight-

est inconvenience. In this connection the case of sewer men, who are notoriously healthy subjects, may be instanced.

Although these investigations seem to establish pretty clearly that sewer air, as such, is not necessarily dangerous, and that the probability of sewer air organisms being carried into the outer air so as to become a danger is exceedingly remote, yet it must be admitted that there is still an off-chance, and it is that off-chance which produces a doubt.

There is still a belief that, for some as yet unknown reason, sewer air escaping direct into dwelling houses is a danger, and that sewer smells are objectionable and a nuisance no one will deny. The public therefore will probably await the result of further investigation.

W. McKerron presented the treasurer's accounts, which were referred to the auditors.

The librarian's report was presented by H. Piers, showing that 1911 books and pamphlets had been received by the Institute through its exchange-list during the year 1905; and 1,457 had been received during ten months (January to October) of the present year, 1906. Particulars were also given of the total number of books and pamphlets received by the Provincial Science Library (with which the books of the Institute are incorporated) during the year 1905. This number was 2,590, of which 1,911 were the society's exchanges as above-mentioned. Increased use of the library was reported, as shown by the number of books borrowed, namely 536 in 1905. A card catalogue of the manuals and general works, arranged alphabetically by authors and subjects, has been completed during 1906, and these books have been arranged on the shelves according to the decimal system of classification. The report was received and adopted.

The Secretary reported that the Kings County Branch of the Institute had done no work during the session of 1905-6, nor during the previous session. It was resolved that the subject of branch societies be referred to the incoming council.

It was resolved that the thanks of the Institute be conveyed to HIS HONOR THE SPEAKER OF THE HOUSE OF ASSEMBLY, for his courtesy in permitting the use of the assembly room as a place of meeting.

Reference was made to the desirability of having some exchange system in Canada which would take the place of that of the Smithsonian Bureau of International Exchanges at Washington, which latter bureau can not now undertake the work of forwarding book packages to foreign countries owing to the magnitude to which such work had grown of late years. The subject was referred to the council.

The following were elected officers for the ensuing year (1906-1907):

President—F. W. W. DOANE, C. E., *ex officio* F. R. M. S.

Vice-Presidents—PROFESSOR EBENEZER MACKAY, PH. D.; PROFESSOR J. E. WOODMAN, D. SC.

Treasurer—J. B. MCCARTHY, B. A., M. SC.

Corresponding Secretary—A. H. MACKAY, LL. D., F. R. S. C.

Recording Secretary—HARRY PIERS.

Librarian—HARRY PIERS.

Councillors without Office—MAYNARD BOWMAN, B. A.; WATSON L. BISHOP; EDWIN GILPIN, JR., LL. D., F. R. S. C., I. S. O.; ALEXANDER MCKAY; PROFESSOR FREDERIC H. SEXTON, B. SC.; HENRY S. POOLE, D. SC., F. R. S. C.; WILLIAM MCKERRON.

Auditors—PROFESSOR D. A. MURRAY, PH. D.; R. MCCOLL, C. E

A vote of thanks was presented to the retiring treasurer, W. MCKERRON, for his services; to H. PIERS, for his work as secretary; and to the PRESIDENT, MR. DOANE.

FIRST ORDINARY MEETING.

Assembly Room, Province Building, Halifax, 14th Jan., 1907.

THE PRESIDENT, MR. DOANE, in the chair.

It was reported that PHILIP A. FREEMAN, engineer, Halifax Electric Tram Co., Halifax, had been elected an ordinary member.

A paper was read, entitled, "Notes on Mineral Fuels of Canada," by R. W. ELLS, LL. D., F. G. S. A., F. R. S. C., of the Geological Survey, Ottawa. (See Transactions, p. 61.)

SECOND ORDINARY MEETING.

City Council Chamber, Halifax, 11th March, 1907.

THE PRESIDENT, MR. DOANE, in the chair.

H. PIERS and J. B. MCCARTHY were appointed a committee to prepare a suitable design for a seal for the Institute, and to have the same engraved.

In the absence of the author, MR. PIERS read the following paper by GENERAL CAMPBELL HARDY:

REMINISCENCES OF A NOVA SCOTIAN NATURALIST: ANDREW DOWNS.—By MAJOR-GENERAL CAMPBELL HARDY, R. A., Dover, England.

In days gone by, when the writer of this paper was quartered at Halifax, N. S., then a great naval and military station of the imperial government, there were two interesting spots which a stranger generally visited first, namely the Old Point Woods and Downs's Zoological Gardens at the head of the North West Arm. The former are now enclosed and preserved in the area termed Point Pleasant Park: the latter have vanished from the scene. It is then the object of this paper to recall a picture of the past, to speak of the remarkable man who lived at the head of the North West Arm, and to describe his charming location, Walton Cottage.*

A little stream runs in at the head of the North West Arm, and following it up by the road which branches from the main road from Halifax in the direction of the Dutch Village, a few hundred yards brought us to Downs's gates.

The cottage nestled in its prettily wooded grounds, with the shores of the Arm in the background receding towards the blue Atlantic. Here nature and cultivation were charmingly blended together, and the wild birds from the hills behind loved to come in and nest in perfect confidence in the owner's good will towards all living creatures. For I will say this of Downs by way of introduc-

*The grounds on which Downs's zoological gardens were situated are now the property of the estate of the late John Doull, and Walton Cottage is at present the residence of Dr. Arthur Doull.

tion, that he was a man of sweet disposition, tender and merciful to all his feathered friends, and though perhaps he could not say yes to Emerson's pointed question, "Hast thous named all the birds without a gun?" he was incapable of any act of cruelty or neglect.

My acquaintance with Downs commenced very soon after arrival, for in him I found the very man who could tell me all about the wild creatures of this favoured little province, the ideal home of the naturalist and sportsman. To live and camp in the great backwoods of Canada had been mv ambition in early youth, and in his company I served an apprenticeship as it were, and commenced habits of observation which have stored my memory with the songs and scents of the woods and the ways of their denizens during a prolonged residence of some sixteen years.

In re-reading lately a very entertaining little book by Samuel Smiles, entitled "The Life of a Scotch Naturalist," I was struck by some points of resemblance between its subject, Thomas Edward, A. L. S., and Andrew Downs of Nova Scotia. Both were men of humble origin, and both became in their early lives devotees of nature study as it is now popularly termed, leaving their respective callings to work in that fascinating field. Both were strenuous workers, taxidermists and collectors, practical men and not over much given to library lore. Both were recognized by the scientific world as having acquired their knowledge of natural history at first-hand, and though cultivating their own powers of observation. It seems, too, that they had much similarity of character, the same honest grasping of facts and hatred of shams, the same Spartan-like simplicity of life, with much originality and a sturdy independence which under all circumstances compels respect. Edward was credited with many discoveries and additions to British zoology. Downs gave more impetus to forwarding the knowledge of local natural history than any Canadian before his day. Every visitor desirous of acquaintance with wild life in the woods or by the waters of Acadie, went to Downs for advice or reference; and few returned to Europe, after a sojourn more or less prolonged in the maritime provinces, without taking back either some trophy of the larger game or specimens of the beautiful avi-fauna of eastern Canada which had passed through our naturalist's skilful hands.

An extended biographical sketch of Downs's life on the model of Smiles's little work would doubtless be very interesting, but as he was a man who sought retirement and seldom troubled himself with correspondence, and as, moreover, time is fast effacing his memory in Nova Scotia, it would be difficult to get together sufficient and reliable materials for such a compilation. I have, however, recently received from the recording secretary of the Nova Scotian Institute of Science,* of which I am a corresponding member, a paper on this subject written by himself and embodying extracts from an article by the editor of the New York *Forest and Stream,* a personal friend and admirer of Downs, whom he had visited. On reading it, I was induced to refer to a number of old diaries and notebooks of Nova Scotian days, and was glad to find Downs's name frequently occurring therein, as well as an article which I contributed in 1864 to a Halifax newspaper* and have fortunately preserved, undoubtedly the first notice of Downs and his establistment which had then been published. I quote the article here, as a contemporary account of the naturalist and his interesting collection of animals:

Sketches in Our Neighbourhood: An Afternoon with Downs.

Half an hour's walk from the city, over the Common, and down the telegraph-road leading to the west, brings the visitor to the cross-roads at the head of the North West Arm. If a stranger, your question—"Is this the way to Downs's?" is probably answered by a piscatorial urchin, seated by a little brook which here trickles into the salt-water under a bridge, by "Yaas, that's it, where yer hear them burds screaming'," pointing to the road turning off towards the Dutch Village. In confirmation whereof the shrill scream of a peacock or discordant cry of a cockatoo reaches your ear, and we presently arrive at the gates of Walton Cottage Gardens.

And here let me say ere proceeding, that these gardens were the first "Zoo" established on the American continent—a fact often recounted to me by the founder with some pride.

Prettily surrounded and hid from the road by fir woods, Downs's house, approached by a circular drive, stands on a slight eminence overlooking the whole length of the North West Arm. It is a neat, rustic little residence with tall, sharp-pointed gables ornamented with trellis,

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*Harry Piers, Esq. See "Sketch of the Life of Andrew Downs, founder of the first zoological garden in America."—*Proc. N. S. Inst. Sci.*, vol. x, p. cii, with portrait.

† *The Acadian Recorder*, edited by Mr. Peter Hamilton and Hunter Duvar.

and a porch groaning under the weight of the honeysuckles and Virginia creepers which have seized upon it. Several pairs of antlers of moose and deer adorn the sides under the roof; and tall poles, bearing painted miniature cottages, are planted around for the express benefit of such birds as will take advantage of the gratuitous lodging thus afforded, and the offer of free board with the well-fed poultry in the yard—a spacious enclosure with a large, clear pond fed by a stream from the hill-side in the rear, and shaded by shrubberies, through which are cut prettily-winding walks in every direction.

Here we probably find the owner himself spreading Indian corn broadcast amongst a rude, greedy assembly of every kind of fowl—land-fowl and water-fowl, great thick-thighed cochins and diminutive bantams, hearty swans which come up to the banquet, with a hasty, waddling gait ill befitting their dignity, and fat, glossy ducks of every hue that at once suggest the idea of comestibles in the shape of green pease. In fact, I was about to pass them over as being, in the language of the advertisers, "too numerous to mention," but as Downs himself is engaged in feeding them, it is worth our while to stay and hear him expatiate on their beauties and peculiarities; for he is a quick, sharp-sighted, and enthusiastic naturalist, and will point out things which we should otherwise have never thought of noticing. "There are days," he says, "when the light seems to bring out the colours on birds' feathers which you would never see in dull weather, days when all nature seems brightened up by the peculiar state of the atmosphere; when the trees seem greener, when the sky has a greater softness and depth than commonly, and your own feelings are in tune with all around. Look at that wild turkey as he comes swelling along, and the sun's rays light up the wonderful metallic hues on the neck, back and sides, hues of bronze, and green, and orange-copper, which now and then flash with the brilliancy of the humming bird's plumage." A pair of pigeons alight at your feet, bowing and scraping around. Perhaps a delicate plum-bloom appears to colour their necks and breasts; but in a moment they burn with emerald green, and in another with the sparkling tints of hyacinth or topaz. These brilliant greens placed on a subdued ground-colour, and changing into the gleaming tints of precious minerals, are favourite touches of nature's pencil from amongst the wide range of colours with which she has so lavishly painted the plumage of birds. The beautiful pencil marking on the silver Hamburgs are pointed out to us, and the bright golden spangles on another variety of domestic fowls. The uncomfortable appearance of the little fowls from China with all their feathers curled back, and the curious blue ear-lobes of the Japanese, which have a blue skin underneath their white feathers and blue bones likewise; the beautiful green velvet jacket which sits so trim and close on the East Indian duck, are all brought under notice by the zealous exhibitor, and the uncouth—stay, I have used a wrong word, and shall be presently corrected by Downs himself, with whom

I heartily agree that there is nothing really ugly or frightful in nature, and though these terms are often employed conventionally, it is really very snobbish to do so, unless in the case of accident or design, by which nature has been made to fall short of her work. It appears to me the height of arrogance to criticize or disparage any of nature's handiwork. Wherein lies our ability to judge? "Ask a toad," says Voltaire, "what is beauty, the supremely beautiful, the *τό καλόν*! He will tell you, it is my wife, with two large eyes projecting out of her little head, a broad and flat neck, yellow belly, and dark brown back." So, friend visitor, be warned not to revile even the toad in the presence of our naturalist, or perchance he may cause thee to be ashamed of thy speech.

Within a little paled enclosure adjacent to the yard are the wood-ducks, the gems of the collection. To see these beautiful birds looking their best, we must choose a bright day, such as has been described. No stuffed specimens can show the vivid colouring of the living and healthy bird in its prime. Many of the glossy hues fade in death, as well as the rich colouring on the upper mandible, of the iris and legs, and which cannot be artifically rendered with justice to the bright tints of life. The wood-duck, so called from its habit of roosting and building in trees, is a rather rare summer visitor in this province. It loves to make its nest in hollows in tall trees, by the banks of forest streams far from the haunts of man. Its Latin name (*Anas sponsa*) signifies the bride-duck, "a pretty name for a pretty creature," as Frank Forester says of it. As Downs chases them over the brook which trickles through this enclosure, and up the sunny bank, that we may the better observe the play of the light on their gorgeous plumage, we notice how strictly they keep in pairs, each drake accompanying his soft, modest-looking duck, and continually uttering a little, subdued cry—*peet, peet*. I have seen these birds in their wild state on the Shubenacadie; once on Gold River, and, more frequently, in the wild river solitudes of northern New Brunswick, when, as our invading canoe scared them from their haunts, they would fly down stream, their brightly-painted forms standing out against the dark background of fir-forest in the soft light of a summer's afternoon. A flock of almost equally beautiful little ducks, natives of South America, with less gorgeous, but exquisitely marked plumage and showy crimson spots on the bill, occupies the same cage as the wood-ducks, where also stalks a very conceited and rather obtrusive crane from the Mississippi, who marches around you, apparently earnestly regarding the ground, but really meditating as to the prudence of indulging in an old failing—that of casually driving his long, sharp beak through your boot.

We cannot fail to notice the tameness of the swallows (the white-bellied wood-swallow), which breed in the little boxes set up for them round the house, and sometimes but a few feet above the ground. Quite regardless of your presence, they continue their nest-building or feeding

their young almost within reach of your hand. I like to see these swallow boxes set up round country houses; they seldom fail to attract a pair of tenants, and nothing is more pleasing than to hear their twittering song, as they busily flit past the window, when awakening on a bright summer's morning.

Many other wild birds also chose these grounds for their family residence. A pair of golden-winged woodpeckers have built in an old stump close to the house for several seasons; robins' nests are met with everywhere; last year a pair hatched two broods in a low fir bush by the side of the glass-house; and in the shrubberies, close to the paths, many varietiees of warblers may constantly be seen throughout the summer flitting to and from their closely-hidden nests. Nor is their confidence misplaced. Downs may apply the words of our gentle-minded Cowper in the "Winter Walk at Noon":

> "These shades are all my own. The timorous hare,
> Grown so familiar with her frequent guest,
> Scarce shuns me; and the stock-dove unalarm'd
> Sits cooing in the pine tree, nor suspends
> His long love-ditty for my near approach."

Sure of protection and ample fare, many migratory birds spend the long, cheerless winter in these grounds. One of these late, cold, dull days, by which the advance of the spring is this year so retarded, I heard the first song-bird here, the joyous note of the song-sparrow emanating from a thicket in the pheasant's enclosure. The little bird had been a guest all winter. Blue-birds (*Junco hiemalis*) and robins also remain. The latter are often seen during this season in many places in the neighbourhood.

It is very satisfactory to see robins and all other small birds now protected by law from being shot within the precincts of the city; whereas formerly they were continually stalked and fired at, particularly in the spring before mating, when the former birds hop over open grass-plots from which the snow has disappeared, in search of worms, in large flocks. Hard times do these appear for the early visitors, and many a buffeting snow-storm and hard-binding frost drives them to the verge of starvation before the new land flows for them with milk and honey, as the numbers of dead robins found on the snow-covered fields in the very cold weather of March, 1863, testified. Instead of cruel persecution, our small birds are deserving of encouragement and protection. In England the long-sustained suspicions of the farmer and the peasant as to the destructiveness of many species have been allayed, and every hedge-row is jubilant with songsters; whereas in France scarce a bird is to be seen in many districts, not only from their supposed noxious qualities, but from the comprehensive spirit of the term "*la chasse*" as pursued by French gunners.

"You call them thieves and pillagers; but know
They are the winged wardens of your farms.
* * * * * * *
And think of your woods and orchards without birds!
Of empty nests that cling to boughs and leaves,
As in an idiot's brain remembered words
Hang empty 'mid the cobwebs of his dreams!"

But to return from this digression to Downs's feathered captives who are apparently not a whit less happy than the wild birds who flit around them.

Leaving the motley assemblage of poultry and water-fowl in the yard, we enter the shrubberies by soft tanned walks along which are scattered the clean-looking, roomy cages allotted to a variety of feathered creatures. Here is an airy little tenement devoted to silver pheasants. The neatness of their plumage and the graceful sweep of their tails render them exceedingly ornamental; but they are, withal, so pugnacious that two separated males apparently devote their whole lives to pacing up and down the dividing wire netting, challenging each other to mortal combat. The silvery plumage of their necks and backs is beautifully pencilled with minute lines, and strongly relieved by their glossy black breasts and bodies. We so generally see birds with the lightest colours beneath, that, when this rule is excepted, a strange appearance is produced and the bird would almost seem inverted. Another instance is that of our common bob o'Lincoln in its summer dress. Further on, whole groves of young spruces are enclosed and netted over; and against their dark foliage the resplendent plumage of the golden pheasants shines in bright contrast as they run to and from the cover and their little house in the corner. Then there are aviaries with flocks of plump snow-buntings; another where the merle and throstle, so often mentioned in the poetry of the fields of merry England, nestle in the fir tree, happily forgetful of the hawthorn bush or oak coppice; the plumed and Californian quails from the far west pick lazily at ant-hills or squat in groups on the warm, sunny banks, under fern and low bushes tastefully introduced in their enclosures; whilst, in another, the spruce partridge of our own forests may be seen pruning the foliage of his favourite larch or silver-fir.

These grounds offer great natural advantages for the tasteful arrangement of a zoological garden: the sloping hillside topped by thick woods is continually broken by mossy hollows with numerous little brooks to which the woodcock and bittern often resort; and the dry, grassy knolls between are adorned by clumps of young firs and white birches, and the olive green tufts of the ground-juniper, amongst the roots of which the retiring mayflower trails towards the light.

By the side of one of these little valleys, dammed so as to form a miniature lake over which a picturesque rustic bridge is thrown, stands a

building known as the "glass house," a light and ornamental structure of painted wood-work and glass used as a green-house and aviary for rare tropical birds, an aquarium room, and a museum; and from the summit of the tower can be obtained a beautiful view of the grounds and the surrounding scenery.*

The aquarium is very attractive; a constant stream of water, derived from a more elevated pond, flows through all its compartments. Here may be seen many inhabitants of our lakes and streams—the silver dace and the yellow perch, in all respects similar to the English species save in his bright golden hue; the cat-fish of hideous mien, whose wide, gaping jaws and voracity render him the tyrant of the lake; the little terrapin or mud turtle of our alluvial rivers basking on semi-submerged rock-work with gorgeously coloured species from other climes; and several other amphibious reptiles, including the yellow-throated and leopard frogs, and the large yellow-spotted salamander common to our little rocky pools by the road-side, though seldom seen, as it is strictly nocturnal in its habits.

But now let us glance at the birds of prey encaged close by. A splendid pair of bald-headed eagles at once arrest our attention, though they have not arrived at the mature age necessary to produce the condition of plumage from which their misnomer, "bald-headed," has been derived. In the adult bird the head, neck and tail become pure white; the pointed hackles of the neck laying in sharp regularity on the close bronze plumage of the bird's body. The iris, beak, nostrils and legs assume a bright golden orange hue. This is the chosen emblem of the United States—the bird of America. The description given of its habit of depriving the osprey of its finny prey, by the great ornithologist of this continent. Wilson, is a beautiful piece of composition; as likewise is that of Audubon, the subject of which is the eagle's attack upon the wild swan in mid-air. There is about this bird an unmistakable air of fierceness and intractability; and it continually indulges in a habit of throwing back its head and giving vent to screams of defiance which must strike terror into the breasts of the captives around.

In adjacent cages sit several specimens of our native birds of wisdom—the owls. These are the great horned owls whose deep-toned hooting emanating from the dark spruce swamps is so familiar to the sojourner in the woods. Heard on a calm, still night in the forest, this sound is most impressive, and, though so connected with melancholy associations, it brings with it nevertheless a strange feeling of pleasure, probably owing to the mournful notes harmonizing with the mystery with which our imagination delights to invest the woods at night, especially when fitfully illumined by the moon. There is a dapper little owl of this species—quite a beau, trim in plumage and wide-awake—confined in one of these cages, who will treat us to some of his music whenever we approach him; and we see, if we look closely, that in emitting the sound, the bill is not opened

* The glass-house is now (1908) almost in ruins.

in the least; the sound is very gutteral and the throat swells to a large hemispherical bag and at the same time the tail is raised. The older birds of his species sit far back in the shade under the sloping roof, apparently absorbed in moody reflection; for we cannot look at their great eyes, over which the covering membrane, which acts as an eyelid, slowly falls and is withdrawn, and the apparent abstraction evinced by their form and attitude, without fancying them to be cogitating deeply.

> "Upon a beam aloft he sits,
> And nods, and seems to think, by fits."

A much brighter-looking bird, however, appears in the form of the snowy owl, confined close by, a stray wanderer from Arctic climes to our woodlands on an extended hunt for rabbits. His quick eyes, which he uses to seek his prey by daylight, unlike most of his family, follow our every movement. Dr. Gilpin states that this bird may be seen sitting in the full glare of the sun, watching the rabbit burrows on the sands of Sable Island, of which he has of late years become a visitor.

Finally our agreeable guide and entertainer conducts us to the top of the hill, where, standing on a huge, erratic boulder of granite which has been left by glacial action in its present site on a bare plateau of slate rock, we may enjoy the beautiful and comprehensive view which opens to us as we turn. Beneath us and at our right are the gardens, with their walks and shrubberies, and the white tops of the bird houses. Beyond, the North West Arm stretches away to the outer harbour; Thrumcap, projecting from the eastern shore, just coming into the picture; and the wooded top of McNab's Island appearing above the south end of the peninsula. The snugly ensconced little sheet of water called Chocolate Lake is partly seen. On the high lands of the peninsula which ridges in front of us, the citadel and its signal station, the common, the fields and farms dotted with white houses, and the wooded spur of Rockhead successively meet our view as we sweep the horizon. Then the blue expanse of Bedford Basin and its distant hills, with the little, white tower of the three-mile church nestling in a fir grove by its shores in the foot of the valley; the picture being bounded on our extreme left by the slopes of Geizer's hill, thickly wooded and skirted at its foot by the road which winds round the valley through the pretty settlement known as the Dutch Village.

And now we retrace our steps, and take leave of our worthy guide with many a good wish for his long enjoyment of the beauties of nature in the pleasant retreat which he has chosen. His conceptions of her teachings, and the mode in which he imparts them to the visitor, are alike original and sound; and few can leave the zoological gardens at the North West Arm without realizing that they have spent a happy afternoon with Downs.

"Happy who walks with him! whom what he finds
Of flavor or of scent in fruit or flower,
Or what he views of beautiful or grand
In nature, from the broad majestic oak
To the green blade that twinkles in the sun,
Prompts with remembrance of a present God."

It was a year or so (it may have been two) after the foregoing article was published that I find in my diary some notes on an incident in which I was much interested at the time, the packing and shipment of some live specimens of moose-deer at Walton Cottage gardens, consigned to Victor Emmanuel, then King of Italy, who was an enthusiastic acclimatizer of large game in his grounds at Pisa. The following is an extract from an account of this incident which I forwarded to the London *Field*. I may here mention that at this time much interest was taken in acclimatization, to forward which there were societies in London, Paris, and elsewhere. In Great Britain the leading men in this direction were Buckland, Grantley, Berkeley, Tegetmeir and others. I have not heard much of this subject of late, but curiously enough saw in a paragraph in my *Morning Post* quite recently a request from the government of New Zealand for as many as fifty moose deer, if procurable, to be forwarded from Canada to the antipodes. Of course the deer would go to the south island where both pine trees and snow are to be found, but what would their food consist of? That would prove, I think, the crux of the experiment.

It appears that Victor Emmanuel, imbued with the spirit of acclimatization, had been procuring a number of the deer of the New World through an agent who made known to our provincial naturalist his majesty's wants with respect to the monarch of the North American forest—the moose. The right man and the right place were selected; but although in no part of North America is the moose-deer more plentiful than in Nova Scotia, living in our small forest areas nearer the borders of civilization than anywhere else, so few of these noble animals are taken young, and successfully reared, that but three could be procured on that occasion throughout the province.

The trio consisted of two cow-moose of the ages of two and a half years and eighteen months, and a sprightly young bull-calf of

seven months, the latter as nearly resembling an overgrown juvenile donkey as could well be imagined on the part of a member of the deer family. The youngest of the cows had been for the past year a much-admired resident in Downs's gardens, where, perfectly domesticated, and roaming in a railed-off patch of its native thickets, it had thriven and afforded much pleasure in contemplation of its strange action and configuration, so often described as uncouth, but so beautifully adapted to its natural state of existence. The larger animal was three-quarters grown, the finest tame specimen I had ever seen; she had been brought in from a distant settlement, the property of a farmer whose clearings verge on woods where moose are plentiful, and had been long a pet of the settlement, feeding with the domestic cattle and from the children's hands, and occasionally roaming at large in the woods. "I can't tell when I can bring her down," said the settler to Downs, when he offered to part with her; "I guess she's away off in the woods just now." But the next time her ladyship took a notion of returning to a state of civilization, the stable door was shut on her, and, driven into a roughly constructed cage of planks, she was shipped and brought down to Halifax in a schooner. A few days after her arrival I went to Downs's gardens to witness the packing of the moose for their voyage to Boston. A little previous fasting, and their excessive fondness for turnips, readily induced them to step boldly into the narrow crates prepared for them, so narrow that when we stuffed in the wadded bolsters to prevent their being injured by struggling or motion on board the packet, it was as tight a fit as could be imagined. "Pack them as tight as they can stand," were the express orders. I never saw animals take such sudden and close confinement so philosophically. Their long heads and prehensile mouffles were stretched out of the apertures in front, eagerly expecting the chopped turnips, without manifesting the least alarm at the novelty of their position; and they were most quietly and satisfactorily drawn into town on a long truck, and swung in their cages on to the deck of the packet. Mr. Downs himself accompanied them, taking plenty of their natural food, i. e. the tops of young birch and maple, and a few evergreen branches, such as the Canadian hemlock and silver fir, to which they are like-

wise partial, especially in winter. The cases were securely lashed across-ship, and the vessel started with favourable auspices. Alas, I have now to chronicle disaster; they made a capital run, almost within sight of Boston light, when one of our terrible mid-winter gales sprang up from the south-west, and drove them nearly the whole distance back. For nearly a week was the vessel most mercilessly buffeted, whilst the seas dashed over her; and under the influence of intense frost everything on board was coated with huge masses of ice. Suffice it to say, that the two smaller moose died from the roughness of the passage and their cramped position. The survivor would doubtless have perished likewise, had not two cages been knocked into one so as to allow her to lie down and stretch her limbs. This she always did when the weather was heaviest, invariably lying with her head towards the seas; and she was landed in Boston, and thence by train at New York in excellent health, and without a gall or scratch. This fine cow—whose value, I almost omitted to mention, was greatly enhanced by her being heavy with calf—was joyfully received by the agent for the King of Italy, and shared with a herd of thirty wapiti (also the property of his majesty, and alike awaiting a passage to Europe), the attentions of many visitors in the Empire City.

Although the passage which has proved so disastrous to the poor moose was unusually rough and protracted, even for a sailing vessel, we have a wrinkle here in connection with shipment of large animals of the deer tribe. Close packing, even with lots of padding, will not answer. Applied, perhaps, to short voyages, and where the animal is restive, it may do; but the exhaustion from a cramped and long-continued position, where it has to bear every shock as part and parcel of the ship, has proved fatal in the cases noted. On the opposite side, witness the largest moose quietly lying down in bad weather as soon as chance to do so was allowed her, and her always adapting her position to the motion of the vessel and the run of the sea. I, therefore, agree with Mr. Downs in the idea that a crate shaped like a hen-coop, well padded on the sides, and especially above, is the best form of cage for transporting large animals of the ruminant order on long sea-voyages.

As a suitable animal for acclimatization in England, I cannot recommend the moose. The great objection is the nature of his food; he is exclusively a wood-eater, living upon the tender branches of deciduous trees, with a proportion, more particularly in winter, of those of evergreens. No plantation or copse in England could thrive with a couple of moose in it; and, though fond of roots, such feeding would prove fatal, as I know from experience; whilst, with one exception, I have never seen a tame moose accept hay or grass. If it were not for this, we would have in the moose an animal most appropriate for acclimatization—with the speed of a trotting horse, the strength and endurance of an ox, a docile and useful beast of burden, and good for food. Its flesh, being very open in its fibre, is very digestible, possessing a good flavour between that of beef and that of venison. It always commands a good price in the market when in season.

Speaking of this animal, the moose was once exceedingly plentiful in the forests of Nova Scotia, and is still holding its own despite increasingly restricted areas, and the large annual tribute it is called on to pay to the sportsman—to say nothing of the poachers, back-wood settlers or greedy Indians. And so the constant employment of Downs as the one taxidermist in the province who could set up a head and horns, can be well imagined. All through the autumn and that part of the winter during which moose-hunting was legal, a stream of trophies from the woods came up to his work-sheds. The skins of the heads were there pickled in preservative liquor in vats, and the horns, with a portion of the frontal bone of the skull, cut out and labelled with the shooter's name. He employed a trusted workman to carve out the pine block (it was always of yellow pine) on which the skins were stretched and united round the horns, which were with the connecting piece of the skull firmly screwed down. It was quite a sight to see these magnificent sporting trophies ranged in his shed. Downs stuffed many hundreds of these moose heads as well as cariboo (I see Mr. Piers states eight hundred in his paper) and they are scattered all through Europe and America. Some I know of are still in good preservation after fifty years of resistance to time and the attacks of moth. One of his finest specimens is (or was) I

believe in Buckingham Palace, having been presented to Her late Majesty Queen Victoria; whilst a whole family stuffed by him appeared in the Nova Scotia Court at the Paris exhibition of 1867. His charge was moderate; I think I used to pay him twenty or twenty-five dollars for setting up my own heads. The true-to-nature modelling of the curious nose of the moose was his forte. The eyes he put in, so he told me, were the upper part of the inturned glass at the bottom of a black bottle. I never heard any-one express aught but delight on receiving his trophy back from the hands of Downs.

To get the heads out of the woods to his establishment what work we sometimes had! To back the huge thing out of the woods, and such woods too, with swarms of blow-flies trying to lay their eggs on it (I am speaking of the warm days of the autumn hunting, in the winter the snow makes it much easier) was often a difficult undertaking even for an Indian, who carries it over his shoulders by the "carrying-strap," and he is liable to have one of the great moose-ticks fasten on his neck—"all same as pieces of fire, he bite." I remember once coming out of Beaver-bank woods, twenty miles from Halifax, with a splendid head we had shot while "calling" the night before. My friend was my guest, who had come out from England to see the woods, and being most anxious to get the head into Downs's pickling tub the same day, I started off with about sixty pounds weight on my back, hop-ing to do it alone, the Indian being obliged to go back to the hunt-ing ground to get the meat with the settlers' help. I did not get far. It was too much, and we had to obtain a cart or rather a waggon.

But to return from this digression to the occupant of Walton Cottage gardens. He called it Walton Cottage after visiting Charles Waterton, of Walton Hall, the author of *Wanderings in South America,* of which more anon. There were many additions to the zoo after my descriptive paper of 1864 was written, to wit bears, polar and black; moose, seal, beaver, etc. White bears are often procurable in Halifax, brought in by vessels trading with Labrador. The specimen I saw at Downs's was always consistently ferocious. Those of the black species, on the other hand, are pleas-ant to have as pets. The Indians often bring them in. I bought

a young one for a dollar which did a deal of damage in my barrack room the first hour I possessed him, and, finally, by attacking my legs, compelled me to get on a chair. But he was an exception. I gave him to an officer going home—poor Welsford who fell at the Redan, and I believe the animal came to a bad end, having injured a child. I gave him porridge and milk, and I well remember his comical snarling face as he greedily plunged his head into it up to his eyes, growling the whole time. My wife and I, visiting Downs's establishment one afternoon, found two young bears encaged there making a great fuss, the owner having gone into town and left them without food—not a usual trait with Downs. I went up the hill to saunter awhile in the woods, and on returning, found her pacifying the youngsters by feeding them out of a child's bottle obtained from the house, one at a time, on her lap, to the astonishment of the boy who was left in charge. Perhaps I had better state here that a young bear, even at mid-summer, is not a very big animal. At birth, generally in February, it is surprisingly diminutive, not more than six inches in length, almost hairless, blind for the first month, and weighs less than a pound; four to six hundred pounds being the weight of the adult bears, *i. e.* the black species, the only one found in Nova Scotia.

Downs had some trouble with his seals. They were the ordinary harbour species (*Phoca vitulina*), frequently seen in Halifax harbour and in the North West Arm. Though wired in an enclosure with a pond and running water, the smell of the sea so near was too much for them, and several times have they been met on the road, bumping themselves along down the hill to the head of the Arm near which, the alarm having been given, they were recaptured.

To Downs the province owes the introduction of both the English pheasant and the Canadian red-deer (*Cervus virginianus*), and I find the following paragraphs in a paper entitled, "Provincial Acclimatization," which I contributed, in December, 1864, to the N. S. Institute of Natural Science, of which I was at that time a vice-president:

"With the fact of the introduction and breeding of the English and gold and silver pheasants at Mr. Downs's establishment we

are well acquainted; and the most interesting fact is the well-ascertained capability of the English pheasant to live and find its own subsistence in our woods through a rigorous winter. Why should not this experiment be continued?"

I have known golden pheasants on the property of Mr. Faulkner, the brewery, Dartmouth, to roost out away from their weather-proof house in the branches of fir trees, uninjured in any way, on a cold night when 23 degrees of frost were registered.

And as to the Virginian deer, the following appears in the same paper:—"The red deer then of Maine and the Canadas, and more recently of New Brunswick, appears to be perfectly adapted for an existence in the Nova Scotian woods—a graceful species, but little inferior to the red deer of Europe, affording the excellent venison with which the New York and Boston markets are so well supplied. Indeed it is already with us, for a small herd of healthy animals may now be seen at Mr. Downs's gardens, to whom the country is already indebted for many an unassisted attempt at real, practical acclimatization."

Between the above and the present date, 1906, this beautiful deer has been turned out and so thriven that it is be found now in every county of the province. Its greatest enemy, the wolf, is not found in Nova Scotia, though frequent in the adjacent intervals a troop of these marauders comes in over the connecting isthmus and is heard of here and there from various counties which it visits, but the species has never been known to stay. There is something about this province which does not suit its fancy. In frequent wanderings I have only once seen the track of a wolf in Nova Scotian woods. It was chasing a young moose in deep snow.

Thanks to the ceaseless efforts of the Game Protection Society which was inaugurated at Halifax in 1852 when I was present, the province has definitely added *Cervus virginianus* to its larger game. It is everywhere increasing. One of the society's agents speaks of it in last year's report as "coming out in the fields among the cattle on several occasions."

Though spoken of in the yearly reports as being found wild here and there, the pheasant is not doing so well, as the fox, the

wild-cat, the eagle, owl, and the rabit-snares are against it, with the great host of the weazel tribe—ermine, mink and marten. Raccoons, too, which are numerous in some parts of the province, are most destructive to game birds nesting on the ground.

In one of his papers on Nova Scotian birds, contributed by Downs to the N. S. Institute of Natural Science in 1865, Downs writes thus of the English sparrow:—"What a treat it would be to see these saucy fellows preening their feathers on our roofs and collecting in dozens round our doors to pick up the scraps, and I would even go so far as to say, gobbling up the cherries in our gardens; for who would not make a sacrifice of some kind to colonize his domain with such a family of merry friends?" Anent which Mr. Harry Piers, the secretary of the Institute, writes me the following answer to a question about the sparrow, dated Halifax, 1904: "Yes, the European sparrow is met with everywhere in Nova Scotia, I am sorry to say. I once was his friend, but with all the evidence there is against him, I have had to turn over to his enemies."

Thoughtlessly brought over the Atlantic to eat up the cankerworm in the trees of American cities, the sparrows did well for a while, but with change of climate soon developed other tastes. They became almost wholly seed and vegetable eaters, devouring young buds on vines and trees, and injuring all cereal crops, so that they are now protested against as bad citizens and criminals and condemned by everyone. They increase very fast and spread everywhere, driving away the native birds, taking their homes and making themselves generally nuisances. The same story comes from Bermuda, where they are driving out the two wild birds of that colony—the beautiful blue and red birds. Another instance of the terrible mistakes which may be made by ill-advised acclimatization.

Although it has been stated that Downs was rather shy of letter-writing, there was one man whose correspondence he prized and whose praises he was never tired of recounting—the veteran naturalist, Charles Waterton, of Walton Hall, Yorks, the author of *Wanderings in South America,* and of many essays on

natural history subjects—"My worthy master in ornithology," he calls him, as he quotes from the well-known book which I own took my own fancy immensely when, as a boy, I first read in its pages the wonders of the South American forest. In those untravelled times there was no library without it. On Downs's return from Europe, which he visited in 1864, being given a free passage in H. M. S. *Mersey,* and taking over many cases of birds as well as a stuffed moose, I went to see him, to hear him recount his adventures. At that time I lived with my family on the shores of the Arm and was a near neighbour. He had received many attentions from savants and had been a guest of Waterton. He spoke of Waterton's tenderness of feeling towards all created things, especially the feathered tribes; how he would allow no guns to be fired by sportsmen or others on his estate, how the wild birds all seemed to understand him, and what a motley gathering there was in the groves and shrubberies of the park at Walton Hall; how he would inveigh against the superficial and absurd natural history as often published in his days both in England and the United States, even Wilson and Audubon coming under the lash of his criticism. "You should hear him," said Downs, "talk of the Hanoverian rat, the only dumb creature I really believe which he really hated." Waterton being of an old English Roman Catholic family which had held Walton Hall for centuries, had no good word for the Hanoverian dynasty, and averred that he had evidence to prove that the grey rat was part of the freight of the vessel that brought over Dutch William. Anyhow, Walton Hall, besides having some of Cromwell's musket balls lodged in the old wood of the house porch, was more than ordinarily troubled by the grey rats, the deadly foes and exterminators of the old English black rat, both in Europe and America, which latter country it very soon reached. I remember a specimen of the black rat being shown at one of our Institute's meetings at Halifax, which had just been killed in Water Street. It was then stated that up to about a century ago it was the common vermin of both countries. In New Zealand, too, the European grey has destroyed the native black rat, once the sole animal food of the Maori, being the only indigenous quadruped of the islands.

Frank Buckland, an old friend of my own, was delighted to meet Downs. Every one of note visited his grounds, including our sovereign, King Edward, the late Duke of Edinburgh, Prince Jerome Bonaparte, and many others. Pleasure excursions to the head of the Arm by steamers often bore numbers of Halifaxians bent on an afternoon's ramble in his charming domain.

Offered the post of superintendent of the New York Central Park Menagerie in 1867, he declined the post through some misunderstanding, and, giving up his grounds at the North West Arm, died in Halifax on 26th August, 1892, aged eighty-one years all but one month.*

In concluding this paper, I think I cannot do better than close with the words of our friend in ending one of his contributions to the proceedings of our Institute, the subject of which was the land birds of Nova Scotia, read in 1865:

"Having now arrived, gentlemen, at the end of my present list, I must state that all the facts I have given may be safely relied on as they are the result of forty years' experience in bird life. And I would, here, as it is the very first time I have ever appeared as a reader in public, take the opportunity of counselling the young men of Halifax to take more interest than they do in the natural history of their country. Many an hour passed in walking up and down Granville Street in tight boots might be devoted far more profitably to studying the quiet scenes of nature. If I had listened to the advice given me by the young men of my time, I do not think I should have had the pleasure of appearing here this evening; and instead of being happy, as I now am, in the presence of my brother naturalists, and possessed of a cheerful home to which I can retire, surrounded by my feathered favourites, I should most probably either have descended to an early grave, or been the habitual frequenter of the tobacco and dram shops. No; the country for me, before all the pleasure and grandeur of the town. Old Waterton once said to me he would sooner be in the woods than in the finest palace in Europe."

* Other particulars regarding his life, and a list of his published papers, will be found in Mr. Piers's article before referred to.

General Hardy's paper was discussed by the PRESIDENT, DR. A. P. REID, DR. A. H. MACKAY, W. L. BISHOP, H. PIERS, and T. C. JAMES.

The SECRETARY was directed to convey to GENERAL HARDY the thanks of the Institute for his interesting communication.

THIRD ORDINARY MEETING.

Assembly Room, Province Building, Halifax, 13th May, 1907.

THE PRESIDENT, MR. DOANE, in the chair.

It was reported that LOUIS L. MOWBRAY, of Hamilton, Bermuda, had been elected a corresponding member.

The SECRETARY read a letter from MR. STUPART, director of the meteorological service, Toronto, informing the society that the self-recording rain-gauge for Halifax, that had been asked for that station in accordance with a resolution of the Institute of 9th April, 1906, had been received by the department and would shortly be installed.

H. PIERS reported on behalf of the committee appointed on 11th March, that the committee had prepared a design for a seal for the Institute, and had had a die engraved, which had been approved by the council.

H. W. JOHNSTON, assistant city engineer, Halifax, read a paper entitled, "The Run-off from a Small Drainage Area near Halifax, N. S.," the drainage area in question being that of Bayer's Lake, a portion of the Chain Lakes water-shed. The subject was discussed by E. L. FENERTY, P. A. FREEMAN, H. PIERS, and the PRESIDENT.

W. L. BISHOP took the chair while the PRESIDENT, F. W. W. DOANE, city engineer, Halifax, read a paper on "Halifax County Water Powers: (1) Starr Manufacturing Company's Power." (See Transactions, p. 21). The subject was discussed by E. L. FENERTY, W. L. BISHOP, P. A. FREEMAN, and others.

HARRY PIERS,
Recording Secretary.

PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1907-1908.

Annual Business Meeting.

Assembly Room, Province Building, Halifax, 11th November, 1907.

The President, F. W. W. Doane, C. E., in the chair.

Presidential Address: (1) Deceased Members; (2) Technical Education.—By F. W. W. Doane, C. E., City Engineer, Halifax.

Gentlemen,—In laying before you a brief review of the events of the past year, one must face the unpleasant duty of recording the losses, with especial reference to those who have answered the last summons.

Since the opening of the last session the Institute has lost some of its oldest members. The death-roll includes Dr. Edwin Gilpin, Hon. D. McN. Parker, Professor George T. Kennedy and Commander E. B. Tinling, R. N.

Dr. Edwin Gilpin, M. A., D. Sc., Ll. D., F. G. S., F. R. S. C., C. I. S. O., who died at Halifax, July 10th, 1907, was the son of the Rev. Dean Gilpin. His mother was a daughter of the late Hon. T. C. Haliburton, the inimitable Nova Scotia humorist, "Sam Slick." Dr. Gilpin was born at Halifax on the 28th day of October, 1850. He attended the Halifax Grammar School, where he was prepared for entrance to

King's College under the able tuition of his father. He received his B. A. degree in 1871, after which he took a special course in mining, geology and chemistry, and received the degree of M. A. in 1873. At the same time he won the "Welsford," "General Williams" and "Alumni" prizes.

After leaving college he began the practical study of mining engineering in Nova Scotia, especially in the Albion collieries of the General Mining Association in Pictou county, and extended his observations in the leading mining districts of Great Britain.

On the 21st day of April, 1879, he was appointed inspector of mines by the government of Nova Scotia. In September 1881 he was appointed a member and made secretary of the board of examiners of colliery officials. In October, 1886, he succeeded to the office of deputy-commissioner of public works and mines.

By royal warrant, November 9th, 1903, Dr. Gilpin shared in the birthday honors conferred by His Majesty. In recognition of continuous, valuable and faithful service to his native province covering a period of one-quarter of a century he received the imperial service order, the presentation being made by the late Lieutenant-Governor Jones on March 23rd, 1904, before an assemblage of prominent citizens. This event was unique, as it was the first presentation of the order made in the province (Dr. Murphy having received his at Ottawa).

Dr. Gilpin claimed that he should be numbered among the oldest of those who have been interested in this Institute. At one of our meetings at which he was presiding he stated that he remembered being present and watching as a boy the initiatory meeting of the Institute in January, 1863, being the more interested as the late Dr. J. Bernard Gilpin, his uncle, who read the first paper in our proceedings, took an active part.

His name first appears in our transactions in the record of a meeting held March 10th, 1873, when he contributed a paper on the grouping of the Pictou coal-seams. At this time

he was proposed as an associate member, as he was not then living in Halifax. His uncle, then vice-president, was in the chair. He was elected April 11th, 1873, and became a member on his removal to Halifax in 1879. He was elected a member of council in 1881, and was re-elected at each annual meeting since that date. In 1894-5 he was vice-president, and in 1895-6 and 1896-7 he held the office of president. For twenty-five years, therefore, he was prominent in the management of the affairs of the Institute, while the period of his membership extended over thirty-four years. The value of his services to the society can be appreciated best by those members who were intimately associated with him in scientific work.

During his membership he communicated to the Institute twenty-six papers principally in the department of geology and mineralogy. While his work as published in our transactions covers a large field and contributes most valuable information regarding the mineral resources of the province, it by no means includes all the publications from his pen. He was the author of a popular work on the "Mines and Mineral Lands of Nova Scotia" published in 1883, and of able contributions to the transactions of several other societies including the North of England Institute of Mining Engineers. His exhaustive reports to the government of Nova Scotia attest the ability of the man in the work for which he was chosen. He was one of the original members of the Royal Society of Canada, was elected a fellow of the Geological Society of London, England, March 11th, 1874, and was a member of the American Institute of Mining Engineers and the Canadian Society of Civil Engineers. In the latter society he was a member of council in 1889.

The degree of D. Sc. was conferred upon him by King's College, and that of LL. D. by Dalhousie University. In the latter he was a member of the faculty of pure and applied science, and lecturer on coal mining.

The news of his death was received with general regret in his native city; in the province where through his life work

he was known widely, personally and professionally; and throughout Canada where his eminent knowledge made him intimate with many leading scientists. To the Institute the loss is a serious one, while to those amongst us who have been associated with him for years, who have known the kindly nature of the man, the quiet humor inherited from his grandfather and his readiness to advise and assist especially the younger workers, the loss is a personal one—that of a friend who had won our sincere respect, esteem and affection.

Hon. Daniel McNeil Parker, M. D., who died at Dartmouth, November 4th, 1907, was the son of Francis Parker and Janet McNeil, descendants of Loyalist ancestry. He was born at Windsor, April 28th, 1822, and received his preparatory training at the Collegiate School, Windsor, and at Horton Academy. His preliminary medical studies were pursued with M. B. Almon, M. D., in Halifax. In 1841 he went to Edinburgh to complete his education. In 1845 he received his diploma from the Royal College of Surgeons, and a gold medal for surgery. In August of the same year he graduated M. D. from Edinburgh University.

On his return to his native province he began the practice of his profession, which continued for fifty years. To perfect his knowledge of surgery he spent two years—1871 and 1873—in Edinburgh. On his return he opened an office as consulting surgeon. It is claimed that he was the first surgeon in Halifax to perform an operation with the use of an anaesthetic, having first had it administered to himself to prove its safety. The first case in Halifax of the removal of ovarian tumors—which had counted their victims by hundreds and thousands—is said to have been performed by Dr. Parker, he having assisted Dr. Keith of Edinburgh, the distinguished specialist in such operations.

During his long and honorable career he was president of the Nova Scotia and Dominion Medical Associations, a member of most of the boards governing the charitable institutions of the city, the hospitals, Y. M. C. A., Industrial School, etc.

In no institution did he take more interest than in the School for the Deaf and Dumb. He was its president for thirty years. He was commissioner of schools, governor of Acadia College for twenty-five years, president of the Baptist Convention and held many other offices.

He was appointed commissioner to the London exhibition in 1851 by the Nova Scotia government, and received from the Prince Consort a commemoration medal. He was a member of the legislative council of his native province from 1867 to 1899, when failing health compelled him to resign.

He was a life member of the Institute, being elected during the session of 1870-71.

In all branches of the art and science of medicine great advances were made during the long period covered by his practice; but he was ever in touch with the times, a diligent student in progressive science.

He guarded zealously all legislation relating to the work of the medical profession, and with the late Dr. Edward Farrell, was behind the act which created the existing sanitary system of the city, and led to the great improvement that has been made in the sanitary condition of Halifax.

His kindness of heart and genial and courtly manner made him a general favorite, while his unquestioned integrity, energy, activity and devotion to duty, won for him the esteem, trust and honor of his fellow men.

Professor George Thomas Kennedy, M. A., D. Sc., F. G. S., died at Wolfville, March 1st, 1907. He was a son of the late William Kennedy of York, England. Dr. Kennedy was born in Montreal January 4th, 1845. He received the rudiments of his education at the Church Colonial School and McGill Model and High Schools. He then entered McGill University, and took his B. A. degree with first-class honors in natural science in 1868, M. A. in 1872, and B. Sc. in 1873.

In 1869-70 he attended the Sheffield Scientific School at Yale College, New Haven, where he took a select course of post graduate studies, including practical chemistry, miner-

alogy, mining, assaying, German, etc. On his return to Montreal he became assistant to Sir J. W. Dawson in the chemical laboratory and museum of McGill College, and later he entered the applied science department of that university from which position he retired to accept an appointment to the chair of chemistry and natural science in Acadia College, Wolfville. Resigning in 1881 he was appointed in the following year professor of chemistry and geology in King's College, Windsor. He was also for some years librarian and curator of the college museum and vice-president of the council.

Professor Kennedy has aided in the work of the Canadian Geological Survey in various ways and conducted for a number of years a series of interesting observations in reference to maritime life in the Gulf of St. Lawrence.

He has been an associate member of the Institute since November 9th, 1882, and was also an associate member of nearly all of the scientific societies in Canada, a member of the American and of the British Association for the Advancement of Science, and a fellow of the Geological Society of London, England. He received his honorary degree of D.Sc. from King's College in 1890. As a geologist, mineralogist and zoologist he occupied no inferior rank in the Dominion of Canada.

Captain E. B. Tinling died at Halifax December 22nd, 1906. He was born in 1849, and entered the British navy at an early age. After rising to the rank of commander he secured commutation of his service and retired, going to Winnipeg, where he purchased a farm. Later he commanded a passenger steamer on the Pacific, but forfeited that position when an act was passed providing that captains of United States passenger steamers should be citizens of that country. Later he received an appointment in the marine department, and for some time previous to his death was stationed in Halifax as nautical examiner. He had been a member of the Institute for a short time only.

Treasurer's Report

The removal of Mr. McCarthy from Halifax left us without a treasurer. He had reorganized and systematized the financial work and was making good progress in bringing it up to date. His books are submitted to-night and a financial statement can be given from them.

Technical Education.

In the rapid march of science no more important step has been noted during the year just closing nor in the annals of the Institute than the manly stride taken by the government of Nova Scotia in providing for the establishment of a Technical College and local technical schools. "The technical education act" was passed since our last annual meeting, and at this moment a technical school is being opened in the city of Halifax. So much has been said, written and published during the last two years in reference to the advantages to be gained by, and the necessity for, the establishment of such educational institutions, that a brief reference only must be permitted in these rambling remarks.

The members of the Institute will remember with pride that Prof. J. G. MacGregor, who held office in our society for years, strongly impressed upon the public the necessity for this important educational move. About a quarter of a century ago, before the rapid growth of correspondence schools had commenced, he pointed out the incompleteness of our educational system, the handicap suffered by our young men through lack of training in scientific methods and the loss to the country in consequence of the absence of modern methods in industrial occupations.

The purpose of the technical college at Halifax being to afford instruction and professional training in metallurgical, civil, mining, mechanical, chemical and electrical engineering and for scientific research, it cannot fail to stimulate the Institute, add to its membership, increase the value of its transactions, introduce new workers in the different departments of science and inject new life.

The central institution will have a corps of skilled scientific men, and thoroughly equipped laboratories in which can be solved the problems that perplex our local engineers, manufacturers, miners, metallurgists, etc. Building stones, woods, cements, iron and steel and all our local products that may be used in the construction of bridges, roads, buildings, piers, docks and other structures can be tested, and data of inestimable value furnished to the Nova Scotia engineer. Ores, coals, cokes, metallurgical processes can be tested and investigated to the profit of the owner and of the province.

In every branch of engineering, the practising engineer is too frequently confronted with the uncomfortable fact that basic data relating to many features of his work are either lacking altogether, or are existent in very meager and more or less intangible form. This unfortunate condition prevails to-day, not so much on account of a dearth of opportunity to acquire the information as for other reasons. These appear to be: first, that many engineers employed on works where data of extreme value can be procured are, or consider themselves to be, too busy to take advantage f their opportunities, continuing to depend upon the work of others; secondly, that a large volume of important information, gathered at the expense of much toil, but under very satisfactory circumstances, is kept for private use alone. Happily such a selfish spirit seems to be rapidly disappearing, and engineers to-day more frequently publish the facts gained privately from research, experiment and practice.

In the realm of theoretical hydraulics, for instance, there are many features of great importance which require accurate demonstration, but which are frequently beyond the province of the practising engineer. The field of research in this branch of engineering alone is a broad one, and the new school of science will have an opportunity to conduct trustworthy investigations the results of which should have a very real value for the profession at large.

We want to know among other things the percentage of rainfall lost by evaporation in Halifax, the run-off from water

sheds and the flow of streams; the precipitation during heavy showers; the best method of protecting cast iron pipes and valves from the effect of salt water; how to preserve cast iron pipes from tuberculation; the best method of preventing the formation of frazil ice; more information about water-hammer in distribution and power line systems; more specific information in reference to the effect of different kinds of water and different classes of sewage on pipes and channels of varying design and material; the best method of harnessing the Bay of Fundy tides; and numerous other facts and fundamental data relating to various branches of hydraulics and hydraulic engineering.

The aim of the old-time military engineer was destruction, the object of the modern engineer is construction, the function of the coming engineer is operation.

To the development of our natural resources we have applied a native energy, some capacity for organization and considerable genius for mechanical affairs. Some portions of the development are done on a great scale, but we often do it very badly. It is time for us to inquire whether the things that we are doing cannot be done better, if in fact others have not developed and put to use much better methods than we are employing.

Although the resources of a country form the basis of its prosperity, much depends on the manner in which these resources are utilized, or in other words on the industrial efficiency of the means and methods of production. We have developed and are developing great transportation systems, we handle raw material on a large scale, machinery has been applied even to the addressing of our letters and affixing stamps; but it remains true, nevertheless, that with a few conspicuous exceptions our manufacturing operations are carried forward in trustful ignorance and disregard of many of the factors upon which real industrial efficiency depends. This is shewn in the stupendous waste which sometimes accompanies the first crude preparation of the raw material; it is shewn in the general absence of a true selective economy in

the apportionment of that raw material among the different industries; and it is shewn again in the losses which attend nearly every step in the progress of the raw material towards the finished product. The absence of proper selective economy in the adaptation of raw material to use is everywhere, as when our railroads use untreated ties and poles, when coal tar is burned as fuel, crystal alum used for purifying water, or valuable publications printed on ground wood papers. We are still polluting our streams with wool grease, still wondering whether we can make alcohol from waste molasses, and still buying coal without reference to heating power.

When wastes so obvious and so easily remedied are everywhere taking heavy toll from our manufacturers, it is not surprising that in all lines of productive effort subtle and elusive problems present themselves and still further lower our industrial efficiency. Steel rails break by thousands; trolley wires snap; boilers corrode; milk cans, wire fences and iron roofing rust; unsightly bloom appears on leather; cloth is stained; paints fail to protect the metal underneath.

In a large proportion of cases those who are confronted by the problem have neither the time, the training nor the equipment required for its solution, and yet such problems and thousands of others far more complex upon their face must be solved if our industrial efficiency is to be brought to its proper level.

No one at all conversant with the facts can doubt that our industrial salvation must be found in a closer alliance between the scientific worker and the actual agencies of production.

Since all material is subject to chemical laws, and its properties and behaviour are influenced or determined by these laws, it follows that a large number, probably by far the greater number of our industrial problems are problems in applied chemistry. No better field for the initiation of work intended to be directly effective in its bearing upon industrial efficiency could therefore be chosen.

In selecting problems, preference should always be given to those which promise in their solution to prove of greatest

benefit to the community. Among subjects which may be suggested for investigation may be mentioned the cause and the prevention of the corrosion of lead pipe, the breakage of steel rails, the waterproofing of cement structures, the utilization of wastes which now involve nuisance and the preservation of iron fences and sheet iron in our climate.

Nothing will convince the average man of the industrial value of research half so quickly as the actual solution of the particular problems by which the individual manufacturer is confronted and perplexed.

In conclusion, before vacating the presidential chair, allow me once more to thank you sincerely for the honor conferred upon me in again electing me to the highest office in the gift of the Institute.

I have much pleasure in opening the forty-sixth session.

It was announced that J. F. WHITEAVES, LL. D., F. G. S., F. R. S. C., etc., palæontologist, zoologist and assistant director of the Geological Survey of Canada, Ontario, had been elected a corresponding member.

The librarian's report was presented by MR. PIERS, showing that 1756 books and pamphlets had been received by the Institute through its exchange-list during the year 1906; and 1,440 had been received during the ten months (January to October) of the present year, 1907. The total number of books and pamphlets received by the Provincial Science Library (with which the books of the Institute are incorporated) during the year 1906, was 2,835. The number of books borrowed in 1906 was 661, as against 539 in the previous year. Reference was also made to the desirability of having restored to the library the annual grant which it had received from the government previous to 1905. The report was received and adopted.

The secretary reported that during the past year no meetings had been held by the King's County Branch of the Institute, and it would have to be considered as having ceased to exist.

It being here reported that probably a new director of the Geological Survey of Canada might be appointed in the near future, some discussion took place as to the desirability of having a man appointed who is familiar with the geology of eastern Canada. The matter was referred to the incoming council.

It was moved that the thanks of the Institute be conveyed to HIS HONOR THE SPEAKER OF THE HOUSE OF ASSEMBLY for his courtesy in permitting the use of the assembly room as a place of meeting.

The thanks of the society were presented to MR. PIERS for his services as secretary.

Discussion took place as to the method of collecting fees, and it was resolved the subject be taken up at the next ordinary meeting.

The following were elected officers for the ensuing year (1907-1908):

President—PROFESSOR EBENEZER MACKAY, PH. D., *ex-officio* F. R. M. S.

Vice-Presidents—PROFESSOR J. EDMUND WOODMAN, D. Sc., and WATSON L. BISHOP.

Treasurer—MAYNARD BOWMAN, B. A.

Recording Secretary—HARRY PIERS.

Librarian—HARRY PIERS.

Councillors without office—ALEXANDER MCKAY; PROFESSOR FREDERIC H. SEXTON, B. S.; HENRY S. POOLE, D. Sc., F. R. S. C.; H. W. JOHNSTON, C. E.; PROFESSOR A. STANLEY MACKENZIE, Ph. D., F. R. S. C.; PHILIP A. FREEMAN; F. W. W. DOANE, C. E.

Auditors—RODERICK MCCOLL, C. E.; WILLIAM MCKERRON.

The thanks of the society were presented to the retiring president, MR. DOANE.

FIRST ORDINARY MEETING.

Assembly Room, Province Building, Halifax, December 9th, 1907.

THE PRESIDENT, DR. EBENEZER MACKAY, in the chair.

H. Jermain M. Creighton, M. A., read a paper "On the Influence of Radium on the Decomposition of Hydriodic Acid." (See Transactions, vol. xii., pt. 1, p. 1). The paper was discussed by the PRESIDENT, DR. MACKENZIE, M. BOWMAN and DR. A. H. MACKAY.

SECOND ORDINARY MEETING.

Legislative Council Chamber, Halifax, 13th Jan., 1908.

THE PRESIDENT, DR. E. MACKAY, in the chair.

It was announced that the following had been elected ordinary members: H. JERMAIN M. CREIGHTON, M. A., Dartmouth; PROFESSOR MURRAY MCNEILL and PROFESSOR A. E. STONE, Dalhousie College, Halifax; A. L. MCCALLUM, B. Sc., analyst, Halifax; GEORGE B. BANCROFT, Halifax County Academy; and A. C. HARLOW, Halifax.

A paper by CLARENCE L. MOORE, M. A., supervisor of schools, Sydney, C. B., on "The Myxomycetes of Pictou County, N. S.," was read by Dr. A. H. MacKay, who supplemented the paper with observations of his own on the subject. (See Transactions, p. 165). The paper was discussed by the PRESIDENT, DR. H. H. READ, W. L. BISHOP and P.A. FREEMAN, and a vote of thanks was passed to MR. MOORE.

THIRD ORDINARY MEETING.

City Council Chamber, Halifax, 12th February, 1908.

THE PRESIDENT, DR. E. MACKAY, in the chair.

The secretary announced that the following had been elected members: ERNEST ROBINSON, B. A., Dartmouth (ordinary), and CLARENCE L. MOORE, M. A., supervisor of schools, Sydney, C. B. (associate).

H. PIERS was requested to interview those interested in order to ascertain what edition will probably be required of the geological survey's forthcoming map-sheets of Halifax.

A. L. MCCALLUM, B. Sc., read a paper on "The Action of Organic Sulphur in Coal during the Coking Process." (See Transactions, p. 212). The subject was discussed by the PRESIDENT, DR. A. H. MACKAY, DR. WOODMAN, M. BOWMAN, P. A. FREEMAN, H. J. M. CREIGHTON, W. H. SOPER, and A. A. HAYWARD. A vote of thanks was presented to the lecturer.

FOURTH ORDINARY MEETING.

Church of England Institute, Halifax, 30th March, 1908.

THE PRESIDENT, DR. E. MACKAY, in the chair.

PROFESSOR E. E. PRINCE, Dominion fishery commissioner, Ottawa, read a paper on "The Fish-eating Habits of Medusæ" and also delivered and address on "The Present and Future of our Fisheries," illustrated by the electric projection lantern. The subject was discussed by S. Y. WILSON, A. H. WHITMAN, and DR. A. H. MACKAY. A vote of thanks was presented to the lecturer.

FIFTH ORDINARY MEETING.

City Council Chamber, Halifax, 13th April, 1908.

THE PRESIDENT, DR. E. MACKAY, in the chair.

H. JERMAIN M. CREIGHTON, M. A., read two papers: (1) "A Few Chemical Changes influenced by Radium: a new method for the detection of Amygdalin" (see Transactions, vol. xii, pt. 1, p. 34); (2) "The Behaviour of Solutions of Hydriodic Acid in Light in the Presence of Oxygen" (see Transactions, vol. xii, pt. 1, p. 49). The papers were discussed by the PRESIDENT, A. L. MCCALLUM, D. M. FERGUSON, and DR. A. S. MACKENZIE.

Sixth Ordinary Meeting.

Assembly Room, Province Building, Halifax, 18th May, 1908.

The President, Dr. E. MacKay, in the chair.

It was announced that H. B. Pickings, department of mines, Halifax, had been elected an ordinary member.

Harry Piers, curator of the Provincial Museum, Halifax, read a paper "On the Occurrence of Tin in Nova Scotia," illustrated by specimens. (See Transactions, p. 239). The subject was discussed by the President, Dr. Woodman, W. L. Bishop, and A. L. McCallum.

Watson L. Bishop, superintendent of water-works, Dartmouth, presented a "Note on Eels in Water-pipes" (see Transactions, p. 640), which was discussed by F. W. W. Doane and John Forbes.

Professor J. E. Woodman, D. Sc., delivered a lecture on the "Economic Geology of Arisaig, N. S.," illustrated by specimens of iron-ore, maps, etc. The subject was discussed by the President, H. Piers, and F. W. W. Doane.

Harry Piers,
Recording Secretary.

XLVII

PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1908-1909

ANNUAL BUSINESS MEETING.

Assembly Committee Room, Province Building, Halifax; 14th October, 1908.

THE PRESIDENT, DR. EBENEZER MACKAY, in the chair.

PRESIDENTIAL ADDRESS: (1) Progress of the Institute since 1890; (2) Progress of Technical Education; (3) Technical Education and Research; (4) The Institute in the Public Service.

By PROFESSOR E. MACKAY, PH. D., Dalhousie College, Halifax.

In opening the present session of the Institute of Science, I wish at the outset to take the opportunity—the first that has presented itself— of expressing to the members of the Institute my appreciation of the honor which they conferred upon me one year ago in electing me to occupy the chair.

It has been the custom to make the opening meeting of each year an occasion for reviewing in its various aspects the work of the past, and especially that of the past year. In accordance with this usage we are to receive reports on our library and our finances, and it is my duty and privilege to present to you some report upon our present condition and activity as a scientific organization.

Progress of the Institute since 1890.

The Institute enters to-night upon the forty-seventh year of its existence. It is, therefore, old enough to permit us to indulge in the exercise of looking backward with some interest and not, I hope, without profit.

In 1890 the Nova Scotian Institute of Natural Science became incorporated under the title of the "Nova Scotian Institute of Science," thus proclaiming by its name what it had previously acknowledged by its practice, that it took the whole domain of science for its province. I shall select the date of this change as setting a convenient limit to a brief retrospective glance at the work of our society in the past. A survey of this period, covering nearly two decades, should furnish some help in answering the question which is always of vital interest to a live organization: Are we making progress? With this in view I have collected some statistics for the period mentioned showing (1) the number and length of the papers contributed each year and subsequently published in the Transactions, and (2) the total number of members for each year of the period.

First, then, as regards the papers, I find that for the sixteen years ending in May, 1906, the last for which complete data are available, there were 153 papers contributed, averaging about 13 pages in length. This gives an average annual contribution of rather less than 10 papers, or in the aggregate, about 131 pages. To show how these contributions have been distributed over the above period, I have plotted two curves, one showing the variation in the aggregate number of pages presented each year and the other the variation in the number of papers. It is seen that with the exception of a depression in 1892-3, and again in 1896-9, the number of papers keeps pretty uniformly in the neighborhood of 10. The curve of pages shows much greater variation. The minimum is reached in the first year of the present century, the maximum three years later, in 1904-5. If we divide the period of sixteen years for which the curve is drawn, into two equal parts of eight years each, it will be found that the average annual contribution for the last eight years is 155 pages, or about 50 pages more than the average for the first eight. We must not, of

course, infer too hastily on this account that real progress has been made; for knowledge is not always advanced in proportion to the number of pages published in the name of science. But whether to be taken as an index of progress or not, there can be no doubt that the papers published in the Transactions are gradually becoming longer. In an opening address to the Institute in 1888 Professor MacGregor stated that the average length of paper given to the Institute for the first quarter century of its existence was 9 pages. The average for the sixteen years previous to 1907 was, as we have seen, 13 pages, and for the last eight years of the same period 15 ½ pages.

During the past year eleven contributions were presented, of which four were biological, four chemical, and three related to geology and mineralogy. It is probable that in volume these will at least equal the average for recent years.

To turn now to statistics of membership, the Institute started in 1890 with a total membership of 91. This number rose to 134 in 1897 and to a maximum of 136 in 1899. It then fell somewhat abruptly to 110 in 1901, and remained at about this number until 1906, when it fell to 104. The rapid decline for the two years following 1899 is not to be considered a mark of decay. It merely signifies that inactive members had been dropped from the list.

It is pleasant to be able to report that during the past year our membership suffered no losses by death. One ordinary member resigned owing to his removal from the province. At the same time one corresponding and nine ordinary members were added to our number. This is a gratifying increase; but more gratifying still is the fact that from these new members came five papers or nearly half of the total contributions for the year.

Progress of Technical Education.

Viewing the present prospects of the Institute in the light of past achievement we find on the whole much encouragement to renewed effort in the future. Progress has not been rapid, but there is reason to think it has been real. So much is a fair inference from the facts that have just been presented. And if we look beyond the walls of the Institute we shall find in some

respects still greater cause for hopefulness. Take the recent progress of technical education for example. In reading the addresses to the Institute of eighteen years ago and of some succeeding years, one is struck with the spirit of hopeless resignation in which the question of technical education is discussed. The speakers, while realizing fully the need for industrial education, saw no prospect of adequate provision being made for it. In contrast with that outlook, we are now able to look forward with confidence to seeing in the early future fully developed courses of all grades in applied science placed within the reach of every deserving boy in Nova Scotia. Here, then, at least, we have progress gratifying in the highest degree to members of a scientific association such as this.

Technical Education and Research.

It is not to be expected that this extension of our educational system will produce any immediate effect in increasing the amount of research. For some time the whole energy of the new department will have to be expended in developing courses for mechanics and miners on the one hand and for engineers on the other. But when these initial difficulties have been overcome we may hope that neither men nor means will be wanting to undertake the solution of some of the problems in applied science of most importance to our provincial industries, to devise, for example, improved methods of treating certain of our native ores, to institute careful tests of our native woods, to investigate industrial processes with a view to effecting economies in them, and similar problems. The effect of such investigations would not be merely to benefit directly some particular industry. A much more important and far-reaching effect would be the gradual formation of a bond between scientific research and the industries which might perhaps develop into such an intimate relation as exists, for example, in Germany where the industries lean upon research and research is in turn vitalized by the industries. There is no doubt that a great deal of exceedingly valuable work is done where research has no intimate relation with industries at all. But there is also no doubt that it is in those countries where the most intimte relations between science and industry have been

established that research in both pure and applied science is most vigorous and is pursued with greatest enthusiasm. Whenever directors of industries begin to discover that research men whom they have been accustomed to think unpractical and visionary can, working in their laboratories, sometimes help them in ways that their practical shop-trained workmen were powerless to do, the first step on the road to a complete understanding will have been taken. I believe it is through the work of the technical college on problems having the most obvious practical bearing that there is the best chance of that first step being made possible. Then once the value of research work is appreciated in industrial circles there will no longer be difficulty in getting men to take an interest in scientific work, and our Institute, no longer obliged to go into the highways and hedges in order to compel men to come and fill up its programmes, will be embarrassed with the wealth of papers at its disposal.

There is one mistake which can do a great deal to retard the good understanding between science and industry, from which, if it came about, so much is to be expected. It is the mistake of underestimating the severity of the training required for effective research work in a physical science, and, in consequence over-estimating the value of the half-trained student of science to an employer. The only kind of scientific man who can be of real service in industrial work—unless the service required is some comparatively simple routine analysis—is a man of the highest training. The training of the evening school or of the high school or of the ordinary college course in science is absolutely without value for this purpose.

The Institute in the Public Service.

Last year the Institute endeavoured with some success to arouse public interest in the problems that are embarrassing our fisheries. I would venture to hope that our society, without losing interest in the fisheries, would this year give a share of its attention to one of the most serious industrial problems facing the province—the conservation of our forests. A few weeks ago one of the leading lumbermen of the world, writing in the *London Times,* expressed the opinion, after careful study of the matter,

that at the present rate of destruction the lumber supply of the world would not last more than about thirty years. If that is the case it furnishes a strong additional reason for conserving our Nova Scotian forests. It is wholly unnecessary to tell the members of this Institute in what imminent peril the remnants of our forests are placed by the scourge of fire, and perhaps even more by reckless and wasteful methods of lumbering. This is not the place to suggest what steps should be taken in order to awaken public opinion, which must be first aroused if effective action in the matter is to be possible. I am only concerned at present in urging that where important natural resources are being wasted, it is the duty of a scientific society such as the Institute to do all in its power to arrest the evil. The Institute is the only scientific society in the province and as such should be the official exponent of scientific opinion. It should be able to create what may be called a scientific public opinion powerful enough to make itself felt. It is as true now as in the days of the wise king that "Where there is no vision the people perish." In such a case as the present it is for men of science to supply the lack of vision.

In conclusion let me express the fervent hope that the present session will excel all its predecessors in the value of its work for science and for the community.

In the absence of the Treasurer, the financial report was deferred to a future meeting.

The Librarian's report was presented by MR. PIERS, showing that 1781 books and pamphlets had been received by the Institute through its exchange-list during the year 1907; and 1261 had been received during the nine months of the present year, 1908, viz., January to September, inclusive. The total number of books and pamphlets received by the Provincial Science Library (with which the books of the Institute are incorporated) during the year 1907, was 2510. The number of books borrowed in 1907, was 607, as against 661 in the previous year. The report was received and adopted.

It was resolved that the thanks of the society be conveyed to HIS HONOR THE SPEAKER OF THE HOUSE OF ASSEMBLY, for his

courtesy in permitting the use of the assembly room as a place of meeting.

Attention was drawn to the approaching fiftieth anniversary of the foundation of the Institute, and it was resolved that the incoming council present at a future meeting a preliminary report on the subject of an appropriate celebration of such an anniversary.

The following were elected officers for the ensuing year (1908-1909) :—

President,—PROFESSOR EBENEZER MACKAY, PH. D., *ex-officio* F. R. M. S.

1st Vice-President,—PROFESSOR J. EDMUND WOODMAN, D. Sc.

2nd Vice-President,—WATSON L. BISHOP.

Treasurer,—MAYNARD BOWMAN, B. A.

Corresponding Secretary,—A. H. MACKAY, LL.D., F. R. S. C.

Recording Secretary and Librarian,—HARRY PIERS.

Councillors without office,—ALEXANDER MCKAY; PROFESSOR FREDERIC H. SEXTON, S. B.; H. W. JOHNSTON, C. E.; PROFESSOR A. STANLEY MACKENZIE, PH. D.; PHILIP A. FREEMAN; F. W. W. DOANE, C. E.; A. L. MCCALLUM, S. B.

Auditors,—RODERICK MCCOLL, C. E.; WILLIAM MCKERRON.

FIRST ORDINARY MEETING.

Geological Lecture Room, Dalhousie College, Halifax; 16th November, 1908.

THE PRESIDENT, DR. EBENEZER MACKAY, in the chair.

It was announced that F. H. MCLEARN, Halifax, and W. S. STAPLETON, supervisor of public schools, Dartmouth, had been elected ordinary members.

PROFESSOR J. EDMUND WOODMAN, D. SC., Dalhousie College, read a paper on "Recent Iron and Limestone Investigations in Nova Scotia," the subject being illustrated by specimens, maps and photographs. The paper was discussed by the PRESIDENT, H. PIERS, PROFESSOR F. H. SEXTON, T. VARDY HILL and others.

Second Ordinary Meeting.

Assembly Room, Province Building, Halifax; 14th December, 1908.

The President, Dr. Ebenezer MacKay, in the chair.

Professor J. G. MacGregor of Edinburgh University, was appointed delegate to represent the Institute at the public meeting of the Geological Society of Glasgow, to be held at Glasgow on 28th January, 1909.

A. L. McCallum, B. Sc., Halifax, read a paper "On the Occurrence of Sheelite in Nova Scotia," describing the deposit lately discovered at Moose River gold district, Halifax county. (See Transactions, p. 250.) The paper was discussed by John Forbes, Dr. A. H. MacKay, H. Piers, Dr. Woodman, and others.

In the absence of the author, Dr. A. S. MacKenzie read a paper by Kenneth McIntosh, of St. Peter's, C. B., "On the commonly accepted Axioms in Celestial Mechanics." The subject was discussed by Dr. MacKenzie, the President, Dr. A. H. MacKay, and Dr. Woodman.

Dr. Woodman exhibited a specimen of auriferous quartz with arsenopyrite from the Middle River gold mine, Inverness county.

The Treasurer, M. Bowman, presented his annual report for the past year, showing a balance of $114.92, a reserve fund of $214.95, and a permanent endowment fund of $810.49. The report was received and adopted. It was resolved that the Treasurer prepare a statement of the financial condition of the Institute and the need of funds, and mail the same with a bill for dues to such members as are in arrears, such bills not to include arrears previous to the financial year 1907-8.

Third Ordinary Meeting.

Assembly Room, Province Building, Halifax; 11th January, 1909.

The President, Dr. Ebenezer MacKay, in the chair.

It was announced that Donald M. Fergusson, chemist of the Acadia Sugar Refining Company, Halifax, had been elected an ordinary member.

Mr. Piers drew attention to the map-sheets of Halifax and its vicinity just published by the Geological Survey of Canada, and exhibited the same.

Dr. A. H. MacKay read a paper by Clarence L. Moore, M. A., supervisor of schools, Sydney, C. B., on "Some Nova Scotian Aquatic Fungi," illustrated by drawings of the species described. (See Transactions, p. 217). Dr. MacKay prefixed an account of the characters, etc., of the group to which they belong. The paper was discussed by Dr. Woodman and W. L. Bishop.

The Secretary was directed to write for particulars regarding the conditions governing the application of the Carnegie Research Fund, in order to ascertain if it was available for the purchase of books needed by investigators in this province.

Fourth Ordinary Meeting.

Committee Room, House of Assembly, Halifax; 15th February, 1909.

The President, Dr. Ebenezer MacKay, in the chair.

A paper by Joseph Perrin of McNab's Island, Halifax, and John Russell of Digby, N. S., entitled "Catalogue of Butterflies and Moths, mostly collected in the neighborhood of Halifax and Digby, N. S.," was communicated by H. Piers. (See Transactions, p. 258). A vote of thanks was passed to Messrs. Perrin and Russell for their excellent paper.

Fifth Ordinary Meeting.

Council Chamber, City Hall, Halifax; 8th March, 1909.

The President, Dr. Ebenezer MacKay, in the chair.

Thomas J. McKavanagh, chief electrician of the cable SS. "Minia," read a paper on "Water Purification by Ozone," which was experimentally illustrated. The paper was discussed by the President, W. L. Bishop, F. W. W. Doane, G. M. J. MacKay, and Rev. H. W. Cunningham. A vote of thanks was presented to the lecturer.

SIXTH ORDINARY MEETING.

House of Assembly, Province Building, Halifax; 24th April, 1909.

The FIRST VICE-PRESIDENT, DR. J. E. WOODMAN, in the chair.

The following papers were read:—

(1) "Geological Conditions affecting the Water Supply of Halifax." By H. CAVANAGH and D. STAIRS, Dalhousie College. Discussed by DR. A. H. MACKAY.

(2) "Weathering of Structural Stones in Halifax." By C. J. MACKENZIE and G. L. CRICHTON, Dalhousie College. Discussed by H. PIERS.

(3) "Cement Testing in the Engineering Laboratories of Dalhousie University." By H. W. FLEMMING, Dalhousie College. This paper which gave results of tests made of Sydney slag-cement, was discussed by W. L. BISHOP, A. L. MCCALLUM, T. V. HILL, DR. A. H. MACKAY, H. PIERS, and G. M. J. MACKAY.

(4) "Effects of Ice Action near Grand Lake, Cape Breton county." By W. S. BRODIE, B. A., Lunenburg, N. S. (See Transactions, p. 253). Discussed by DR. A. H. MACKAY.

(5) "The Influence of Aluminium Salts on the Estimation of Sulphates." By H. JERMAIN M. CREIGHTON, M. A., Birmingham University, Birmingham, England. (See Transactions, vol. xii, pt. 2, p. 207).

A vote of thanks was presented to the non-members who had presented papers.

HARRY PIERS,
Recording Secretary.

LVII

PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1909-1910.

ANNUAL BUSINESS MEETING.

House of Assembly, Province Building, Halifax;
8th November, 1909.

THE PRESIDENT, DR. EBENEZER MACKAY, in the chair.

Other members present: DR. A. H. MACKAY, DR. A. STANLEY MACKENZIE, MAYNARD BOWMAN, ALEXANDER MCKAY, WATSON L. BISHOP, F. W. W. DOANE, PARKER R. COLPITT, WILLIAM MCKERRON, THOMAS C. MCKAY, and HARRY PIERS.

PRESIDENTIAL ADDRESS: (1) Deceased members; (2) Work of the Institute; (3) The atomic theory.—By PROFESSOR EBENEZER MACKAY, PH. D., Dalhousie College, Halifax.

Deceased Members.

In reviewing the history of our last year preparatory to beginning, as we do this evening, the work of a new session, it is fitting that reference should first be made to the losses which our membership has sustained through death. It is with profound regret I have to record the death of four members: one associate member, Mr. R. R. McLeod, and three corresponding members, Mr. Charles Pickford, Dr. James Fletcher and Mr. Hugh Fletcher. Of these the last named was, by virtue of his geological work in the Province and his contributions to the Transactions of the Society, associated in an especial way with the work of the Institute.

Mr. Robert Randall McLeod, of Brookfield, Queens County, died at Winthrop, Massachusetts, in February of the present year. Mr. McLeod was a man of high intelligence and wide reading. He was master of an excellent English style, and perhaps no contemporary Nova Scotian author was so well-known to the reading public of the Province. He was besides a true lover of nature and was the author of "In the Acadian Land," a charming series of nature sketches. He was also the author of a work on the resources of Nova Scotia, entitled "Markland."

Mr. Charles Pickford, of Halifax, was never identified with the scientific work of the Institute. But he will be remembered by older members as having done our society the service of attendiing to its financial affairs during the treasurership of the late W. C. Silver.

Dr. James Fletcher, of Ottawa, who died in November, 1908, was one of the foremost Canadian naturalists and was the author of numerous papers on the insect life of Canada. Since 1887 he was entomologist and botanist at the Central Experimental Farm, Ottawa. He was also sometime Honorary Secretary and Treasurer of the Royal Society of Canada, of which he was a Fellow. A man of pleasing personality as well as an accomplished scientist his loss will be felt by a much wider circle than that of his personal friends.

When in last September the death of Mr. Hugh Fletcher was announced through the press, many members of this Society and many others in all sections of the Province felt a sense of personal loss. His death occurred at Lower Cove, Cumberland County, on the 23rd of September. Mr. Fletcher entered the service of the Geological Survey of Canada about thirty years ago, after a brilliant undergraduate course in the University of Toronto. Much of his professional work was done in Nova Scotia and no one else possessed so intimate a knowledge of the geology of this Province as he. His was the ideal scientific temperament —painstaking, accurate and conscientious as an observer, cautious in reaching his conclusions, tolerant of the opinions of others, but firm in his adherence to what he himself believed to be the truth. To the mining interests of the province he rendered notable and widely acknowledged services, and to pure science his work is of

no less value. Mr. Fletcher was much more, however, than a mere geological specialist; he was an accomplished linguist, and a man of wide culture and broad interests. But no sketch of him would be adequate which did not above all recall characteristics of the heart as well as of the head, the lovable personality, the nobility of character, which will make his name long cherished in the wide circle of his friends in Nova Scotia. In Mr. Fletcher's death Canada loses one of its most eminent scientific men and most devoted public servants.

Work of the Institute.

The work of the Institute for the past year has not been characterized by any unusual features. Eleven papers were communicated. Of these four were geological, two botanical, and two chemical, and of the remainder one dealt with celestial mechanics, one with mineralogy, and one with the examination of cement.

Having now submitted some report upon our doings for the past year, I hope I shall be pardoned if, following the practice in many scientific societies, I devote the remainder of the time given me this evening to a brief discussion of a scientific topic.

The Atomic Theory.

The last two decades have been as rich in epoch-making work, at least in the departments of physics and chemistry, as the corresponding decades a century ago which saw the formulation of the laws of definite and multiple proportions and the birth of the atomic theory And some of the most notable discoveries of these two decades have been of such a character as to raise doubt in some minds as to whether Dalton's theory is any longer tenable. On the one hand the investigation of the nature of radiant matter seems to show the existence of bodies a thousand times more minute than the smallest of Dalton's atoms, while on the other hand among many new kinds of matter discovered some have revealed properties of so revolutionary and anarchistic a character as seemingly to threaten the stability of the whole chemical edifice, hitherto thought to be securely founded on its century-old atomic foundations. The statement is frequently heard that these dis-

coveries must revolutionize chemical theories and conceptions. It is my purpose this evening to attempt to show very briefly what the position of the great central theory of modern chemistry is in the light of the most recent investigation.

It is just a year more than a century ago that Dalton published to the world the first full account of his atomic theory, in order to explain the laws of chemical combination which he had himself helped to formulate. The idea that matter has a grained structure, or is composed of minute particles more or less distant from one another, was advanced by one of the early Greek philosophers more than twenty-four centuries ago, and thereafter similar speculations had been from time to time entertained by various poets, philosophers and scientists. But to Dalton is due the credit of first applying these ideas to the explanation of chemical laws, and thereby converting an idle metaphysical speculation into a fruitful scientific theory. The fundamental fact which the atomic theory has to explain is that the combination of elements with one another not only takes place in certain invariable proportions but also that these proportions can all be expressed as integral multiples of certain numbers, one for each element. Thus, the only proportions in which oxygen is known to combine with other elements can be expressed by 16 multiplied by 1, or 2, or 3, or some other whole number. The proportions in which carbon is found in any of its hundred thousand compounds can always be expressed by 12 or some integral multiple of 12. These are the facts. Now it is plain that these facts receive a simple explanation if we suppose that each element is composed of minute particles, all of constant weight for the same element, and that chemical combination takes place between these particles. This was Dalton's atomic hypothesis. According to it, then, elementary matter resembles those articles of commerce that we can only buy in cakes or parcels of a definite weight, like soap. Different elements correspond to different brands of soap, each brand being made up into cakes of a uniform weight, but of different weight from the cakes of any other brand. The association of one or more cakes of one brand with one or more cakes of any other constitutes chemical combination. Now let us suppose our cakes so minute that they are

far beyond the powers of the most delicate balance to weigh or of the most powerful microscope to reveal and we have a fair conception of Dalton's atom and of the atomic hypothesis.

A scientific hypothesis to be of value must serve two purposes: it must satisfactorily explain the facts already known and it must point the way to fresh discoveries. Judged by this criterion, the atomic hypothesis is among the most valuable in the history of science. Its effect in stimulating research was immediate and permanent. Under its influence, in the second decade of the last century, the great Berzelius carried out the gigantic work necessary to establish the laws of chemical proportions, which henceforth became the foundation of all chemical research. And from that time until the present the atomic theory has dominated chemical thought.

Dalton assumed the atom to be indivisible and of constant mass or weight, but made no assumption regarding its other properties, for example, its size or shape or colour or any of its physical characteristics. But as investigation proceeded this conception was modified in two directions. On the one hand the idea was advanced that the atom might itself be composite; on the other hand it was endowed with certain new properties. The first of these modifications was proposed within a decade of Dalton's publication of his theory. Prout, an English physician, observing that atomic weights as then determined were all either whole numbers or very nearly whole numbers if the weight for hydrogen were made unity, put forward the hypothesis that hydrogen was the one primordial substance of which all other elements were composed, their atoms being simply groups of hydrogen atoms. This hypothesis has proved itself one of the most seductive in the history of science. It appealed to the imagination of the chemical philosopher since it revived the ancient idea of the oneness of matter and provided a soul-satisfying unity underlying the infinite multiplicity of chemical changes. It was soon found, however, that several atomic weights could not be expressed by whole numbers. That of chlorine, for example, was certainly nearer 35.5 than 35. To meet these facts it was assumed that the

primordial matter was not hydrogen but something having half that weight; so that the hydrogen atom itself was composite. Afterwards, as methods of determining atomic weights became more refined and the existence of various fractional values in atomic weights could be maintained with certainty, this primordial matter had to be still further subdivided, until its subdivisions became too minute to be capable of verification by chemical analysis. The truth or falsity of the hypothesis could then no longer be tested by experimental methods and the hypothesis itself retreated from the territory of science into that of speculative philosophy. Meantime under the stimulating influence of the atomic theory the investigation of atomic weights and the properties of elements contnued until, a little more than fifty years after the publication of Prout's hypothesis, these investigations blossomed into a generalization which recalled to chemists once more, this time with convincing force, the conception that the atoms must after all be composite substances. This was the Periodic Law of Mendeléeff and Lothar Meyer. If we arrange the elements in a long line in the order of their atomic weights and then observe successively their properties, we find the same set of properties recurring again and again at regular intervals. It is as if we were dealing with a succession of generations, the individuals of each generation reproducing more or less faithfully the characteristics of their respective ancestors. Now we are free to adopt either of two attitudes towards this law. The facts are undeniable: and we may either refuse to speculate about the cause, or we may allow ourselves to indulge in that luxury. If we choose the latter course, it is difficult to avoid the conclusion that our elements are not the ultimate forms of matter; and if we assume the atomic theory, it follows that our atoms are composite.

We now see that the idea of the composite character of atoms is nearly as old as the atomic theory itself and in one form or other, like the poor, has been with us always. But the validity of the atomic theory has not thereby been undermined or in any way affected. For the conception of an atom involved in it is not that it is the smallest particle of matter capable of existence, but is that minute mass of matter which maintains its individuality

throughout all chemical reactions. No difference how composite it may be, if it maintains its unity throughout all chemical operations to which it can be subjected in the laboratory, then it is, so far as the chemist is concerned, indivisible, and constitutes a chemical atom. This is the conception of an atom that has long prevailed in chemical circles.

About ten years ago Sir Joseph Thomson's researches on the nature of radiant matter revealed the existence of corpuscles a thousand times smaller than the hypothetical hydrogen atom of the atomic theory. This great discovery seems to have disturbed the faith of weaker brethren, who imagined they saw in it the approach of a cataclysm which would sweep away old landmarks and leave few or none of our familiar chemical conceptions any longer recognisable. But from what has now been said it will be clear that while the discovery was one of extreme interest to chemistry, it had no tendency to invalidate the atomic theory. The tendency was rather in the opposite direction, since the discovery furnished additional evidence of the existence of extremely minute particles of matter.

Just half a century after the publication of the atomic theory, the progress of chemical knowledge and the corresponding evolution of chemical thought resulted in endowing the atom with a new property, namely, a strictly limited capacity for combining with other atoms, as measured by the number of atoms with which it can combine. This is the property called valency. The facts known were best explained by the assumption that a given atom cannot become directly associated with or, figuratively speaking, linked to, an indefinitely large number of other atoms. On the contrary, the number is at most small, the atoms of each element having a certain maximum capacity of combining. The capacity of the atoms of some elements, hydrogen for example, is exhausted when it has combined with one other atom. An atom of oxygen, on the other hand, can combine with two but with no more than two such atoms as hydrogen. Or again, the limit of combination for an atom of carbon is four atoms of hydrogen or two atoms of oxygen. Hydrogen atoms accordingly are said to have a valence of one, oxygen atoms of two, carbon atoms of four. The highest

valence which any atom exhibits is eight. The effect of this extension of the atomic theory was to vastly increase its usefulness. It now became possible to formulate relationships between the atoms in the molecules of even complex organic compounds. In other words, chemists were now able to form a mental picture of the internal mechanism of molecules of compounds, which, whether it corresponded closely to fact or not, at least justified itself, for it greatly facilitated chemical investigation. A single example will serve to illustrate this. An analysis of acetic acid shows that it is composed of 40.11 per cent. carbon, 6.80 per cent. hydrogen, and 53.09 per cent. oxygen. Expressed in the language of the atomic theory, this composition would be given by the formula CH_2O. Physical as well as chemical considerations lead to a molecular formula just double this, or $C_2H_4O_2$, expressing, of course, the same composition. Now experiment shows that one-quarter and no more than one-quarter of the hydrogen in acetic acid can be replaced by an equivalent weight of a metal, as sodium, yielding sodium acetate. The remaining three-quarters cannot be so replaced. This fact is expressed in terms of the atomic theory by the statement that one hydrogen atom in the molecule of acetic acid bears a relation to it different from that of the other three. Again, experiment shows that in a wide variety of reactions where one-quarter of the hydrogen of the acid is abstracted from it, one-half of the oxygen also disappears at the same time, and these quantities of hydrogen and oxygen reappear again together in one of the products of the reaction. The inference is that part of the oxygen and hydrogen in acetic acid are closely associated, or, in terms of the atomic theory, one of the hydrogen atoms in the molecule is closely combined with, or linked to, one of the oxygen atoms; and as the valence of hydrogen is unity and that of oxygen two, the hydrogen must be attached to the rest of the molecule by means of the oxygen; and hence if the oxygen is split off the hydrogen must go off with it. Proceeding in this way, interpreting experimental results by the atomic theory and its extension in the theory of valency, we finally arrive at a mental picture of the molecular structure, of a compound. Now the important feature is that this mental picture may suggest new methods of

making the compound and may point to new and unexpected properties, which in turn can be verified by further experimentation; and thus knowledge grows from more to more.

A striking illustration of this process is furnished by the benzene theory. This is simply a mental picture of the relation of the atoms in a molecule of the hydrocarbon benzene. Its publication in 1865 led to an unexampled advance in the knowledge of that great class of organic compounds known as benzene derivatives, which include, among many other substances, the aniline dyes; and it was this advance which made possible the great German colour industry of to-day with its millions of capital, its army of workmen and, last but not least, its alluring dividends. No more practical proof than this of the utility of a theory can reasonably be demanded.

But this very utility has had a train of evil consequences. So universally useful has the atomic theory been in explaining the properties of matter that in some quarters the existence of atoms is tacitly assumed as a fact. Careless writers of elementary text-books are especial sinners in this respect, and in consequence many beginners in chemistry acquire as firm a belief in the reality of atoms as in the existence of footballs or chocolates, to the complete subversion of all clear thinking in chemical subjects. I have in mind a text-book of elementary chemistry which I keep by me as a constant reminder of how the subject should not be presented. On one of the first pages of this book, the author, having defined "mass" and "molecule" in the same breath, directs the attention of the student to a piece of sugar and inquiries:

"Cannot the smallest particle of sugar, the molecule, be separated into still smaller particles of something else? May it not be a *compound* body, and will not some force *separate* it into two or more substances? The next experiment will answer this question."

The pupil is then instructed to pour some sulphuric acid on sugar. The sugar is charred, and the author, after pointing out that this action is an example of chemical change continues as follows:

"From this we see that molecules are not the ultimate divisions of matter. The smallest sugar particles are made up of still smaller particles of other things which do not resemble sugar, as a word is composed of letters which alone do not resemble the word."

A few sentences later we have the statement: "An atom is the smallest particle of an element that can enter into combination."

Now, if after faithfully working in the laboratory, book in hand, the high school pupil comes away with the idea that he has proved the existence of atoms, and that there is much the same sort of evidence for their reality as there is for that of sugar, whose fault is it? And if after a course of laboratory training of this sort, he seems to have lost forever the power of drawing from simple experiments the deductions which they warrant and those only, whose fault is it?

While at the present day the atomic theory is at the basis of the explanations of all properties of matter both in chemistry and physics, it has had to be confessed hitherto not only that it has not been proved but that it is perhaps incapable of direct experimental proof.

To understand the difficulty one has only to realize the extreme minuteness of the magnitudes to be dealt with. The calculations of Lord Kelvin and others have shown that, assuming the existence of atoms and molecules, the atom is probably not more than one-millionth of a millimeter in diameter, that is, ten million atoms placed side by side so as to touch one another would just stretch across the nail of one's little finger. Similar calculations show that a cubic centimeter of air, that is, a little cube each edge of which measures about the width of one's little finger nail, would contain under normal conditions twenty million million million molecules, each of them being a group of two atoms. Professor Fleming, of London, gives the following illustration:

"We can in a good Whitworth measuring instrument detect a variation in length of a metal bar equal to one-millionth of an inch. This short length would be occupied by 25 molecules placed in a row together. We can in a good microscope see a small object

whose diameter is one hundred-thousandth of an inch. In a small box of this size we could pack 16 million molecules close together. The smallest weight which can be weighed on a very good chemical balance is one-hundredth of a milligram. The united weight of one million million million molecules of hydrogen would therefore just be detectable on such a balance."

It is not surprising that direct confirmation of the existence of bodies having such infinitesimal magnitudes has seemed hopeless; and in consideration of this there arose a school of chemists in Germany in the last decade of the last century who, with Ostwald at their head, have attempted to dispense with the atomic theory and rebuild the fabric of chemical theory on a surer foundation than an hypothesis at once unproved and seemingly incapable of proof. If this attempt were ultimately approved by the world of physicists and chemists, whatever the philosophic gain might be, the practical loss would undoubtedly be great and the progress of physical science retarded. On this account the recent announcement of Professor Rutherford that he has obtained a direct experimental proof of the existence of atoms is one of unusual interest and importance.

This evidence has come from a quarter from which at one time some timid souls thought present chemical conceptions had much to fear, namely, from the investigation of radio-active matter. The contrary has proved to be the case. Light has already been thrown on atomic structure, of which previously nothing could be asserted, since its problems could not be attacked by ordinary chemical methods. The new knowledge is thus making conceptions more definite which formerly had to be left vague through ignorance. It has not come to destroy but to fulfil.

The brilliant researches of Rutherford and his co-workers on radium and other radio-active matter have led to the conclusion that the astonishing properties of these substances are only to be explained on the assumption that atoms are to be thought of as complex systems and that the atoms of radio-active substances are unstable, some of them constantly undergoing spontaneous decomposition. In decomposing the atom usually projects particles into the surrounding space while at the same time new forms of matter make their appearance.

In the case of radium two kinds of particles are projected with great velocity, α particles of atomic dimensions, and β particles of the same order of size as the corpuscles detected by Sir Joseph Thomson, or a thousand times smaller than an atom of hydrogen. The question at once arises, how is the detection of such minute masses of matter possible? The answer is that these particles are electrically charged and that the possibility of following their movements is thereby almost infinitely increased. Sir Joseph Thomson in his recent presidential address to the British Association at Winnipeg gave a very striking illustration of this fact. The smallest quantity of unelectrified matter ever detected is, probably, a trace of neon amounting to half a millionth of a cubic centimeter. This small quantity would contain about ten million million molecules. "Now", to quote the words of the address, "the population of the earth is estimated at about fifteen hundred millions, so that the smallest number of molecules of neon we can identify is about 7000 times the population of the earth. In other words, if we had no better test for the existence of a man than we have for that of an unelectrified molecule we should come to the conclusion that the earth is uninhabited." On the other hand when molecules are electrified the presence of only three or four of them in a cubic centimeter can be detected.

It was by taking advantage of this fact that Rutherford and his co-workers have recently been able to detect by a special electric method the entrance of a single α particle into a vessel prepared for its reception. The detection was effected by the impulse given to an electrometer needle on the entrance of the particle. The experiment was so arranged that each α particle emitted could be counted by continuing the impulses of the needle. The next step was to allow these α particles to be projected in vast numbers into a suitable receiver previously exhausted. It was found that helium gas accumulated in the receiver. Now it may be shown that, if there are such things as molecules at all, the molecule and atom of helium must be identical, that is, it is what is called a monatomic gas. It follows that the α particles expelled from radium are helium atoms or molecules and hence we have what seems direct experimental proof of the existence of the atom.

This result was confirmed by a second method. Everyone is probably acquainted with the little instrument devised by Sir William Crookes in which a speck of radium set up in front of a screen of phosporescent zinc sulphite under a microscope slide is seen with a lens to produce upon the screen innumerable flashes of light. These scintillations can only be due to the *a* particles emitted by the radium. Rutherford modified this arrangement until the scintillations produced were no more numerous than could be counted, and thus not only had a second demonstration of the existence of atoms but obtained data based on actual counting from which could readily be calculated the number of molecules in a cubic centimeter of gas. Henceforth, therefore, we may feel that the atomic theory, unlike the systems that have their day and cease to be, is to abide with us as a permanent utliity.

The Treasurer, M. BOWMAN, presented his annual report, showing that the receipts for the year ending November, 1909, were $881.92, the expenditures $626.73, and the balance in current account $255.19; while the permanent endowment fund is $834.79, and the reserve fund $18.87. The report, having been audited, was received and adopted.

The Librarian's report was presented by H. PIERS, showing that 1,697 books and pamphlets had been received by the Institute through its exchange-list during the year 1908; and 1189 had been received during the first nine months of the present year (1909), viz., January to September inclusive. The total number of books and pamphlets received by the Provincial Science Library (with which those of the Institute are incorporated) during the year 1908, was 3,761. The number of books borrowed was 381, besides the many that were consulted in the library. No binding has been done for some years owing to lack of funds. Arrangements have been made to move the Provincial Science Library from No. 201 Hollis street to the new Technical College, on Spring Garden road, where it will be placed in a stack-room, 48 by 41 feet, with a small adjoining reading-room, on the second floor of the building.—The report was received and adopted.

The subject of binding volumes in the Institute's library was referred to the incoming council.

On motion of DR. A. H. MACKAY and H. PIERS the following resolution was unanimously adopted:

"Whereas, the Nova Scotian Institute of Science has learned with deep regret of the death of its corresponding-member, Mr. Hugh Fletcher, B. A., geologist of the Canadian Geological Survey, which sad event occurred at Lower Cove, Cumberland county, Nova Scotia, on the 23rd of September, 1909;

"Therefore resolved, that the Institute of Science at its annual meeting held on the 8th of November, 1909, place on record an expression of appreciation of his high scientific and scholarly attainments, of his untiring, enthusiastic, extensive and accurate work in the field of Nova Scotian geology, of his sterling modesty of character, and of his kind disposition and helpfulness towards all with whom he came into touch."

It was resolved that the thanks of the society be conveyed to His Honor, the Speaker of the House of Assembly, and the Hon. the Commissioner of Public Works and Mines for their courtesy in permitting the use of the assembly room as a place of meeting.

The following were elected officers for the ensuing year (1909-10):

President,—Professor Ebenezer Mackay, Ph. D., *ex officio* F. R. M. S.

1st Vice-President,—Watson L. Bishop.

2nd Vice-President,—Professor A. Stanley MacKenzie, Ph. D.

Treasurer,—Maynard Bowman, M. A.

Corresponding Secretary,—A. H. MacKay, Ll. D., F. R. S. C.

Recording Secretary and Librarian,—Harry Piers.

Councillors without office,—Alexander McKay; Professor Frederic H. Sexton, B. Sc.; Philip A. Freeman; Francis W. W. Doane, C. E.; A. L. McCallum, B. Sc.; Donald M. Fergusson; and Parker R. Colpitt.

Auditors.—William McKerron and H. W. Johnston, C. E.

First Ordinary Meeting.

Mining Engineering Lecture Room, N. S. Technical College, Halifax; 13th December, 1909.

The President, Dr. E. Mackay, in the chair.

The President referred to the meeting of the society being held for the first time in the Technical College, at which place future meetings will take place.

It was announced that at the April meeting of the council, W. S. BRODIE, B. A., of Lunenburg, N. S., had been duly elected an associate member.

DR. A. H. MACKAY delivered an address on "A new Nova Scotian insect: the Birch-leaf Saw-fly (*Phlebatrophia mathesoni*, Alex. MacGillivray)." The subject was discussed by MESSRS. DOANE, PIERS, BISHOP and BROWN.

HAROLD S. DAVIS, of Dalhousie University, read a paper prepared by himself and H. W. MATHESON, "On a New Method of estimating Iodides." The paper was discussed by the PRESIDENT, C. B. NICKERSON, D. M. FERGUSSON, and DR. A. H. MACKAY.

SECOND ORDINARY MEETING.

Mining Lecture Room, Technical College, Halifax;
14th February, 1910.

THE PRESIDENT, DR. E. MACKAY, in the chair.

It was announced that at the last meeting of the council, the REVEREND M. C. KELLY, of St. Mary's College, Halifax, had been duly elected an ordinary member.

D. S. MCINTOSH, B. A., B. SC. lecturer on geology, Dalhousie University, read a paper entitled "A Note on the Recent Earthquake in Cape Breton." (See transactions, p. 311). The subject was discussed by PROFESSOR A. S. MACKENZIE; and DR. T. C. MCKAY gave a description of his experience during the late great Californian earthquake, which he illustrated by stereopticon views made from photographs.

T. C. MCKAY, M. A., D. SC., instructor in physics, Dalhousie University, presented a paper on "The Variation of the Hill Effect with the Temperature and Previous Heat Treatment in the case of Magnetic Metals."

PROFESSOR A. S. MACKENZIE followed with a discussion of the phenomena produced by any physical strains causing molecular change in metals.

THIRD ORDINARY MEETING.

Assembly Room, Technical College, Halifax;
11th April, 1910.

THE PRESIDENT, DR. E. MACKAY, in the chair.

PROFESSOR ERNEST HAYCOCK, of Acadia University, Wolfville, read a paper entitled "The History of Erosion in the Cornwallis

Valley, N. S." The paper was discussed by PROFESSOR SEXTON, H. PIERS and D. S. MACINTOSH.

THOMAS J. MCKAVANAGH, electrician of the cable steamship "Minia," gave an address on "Recent Results in Wireless Telegraphy," illustrated by experimental apparatus in operation.

FOURTH ORDINARY MEETING.

Mining Lecture Room, Technical College, Halifax;
9th May, 1910.

THE PRESIDENT, DR. E. MACKAY, in the chair.

On motion of MESSRS. PIERS and MCKERRON, it was resolved that, as a mark of respect to the memory of His late Gracious Majesty, KING EDWARD, the meeting adjourn to this day fortnight.

ADJOURNED FOURTH ORDINARY MEETING.

Mining Lecture Room, Technical College, Halifax;
23rd May, 1910.

THE PRESIDENT, DR. E. MACKAY, in the chair.

The following papers were presented:

(1) "The Rusts of Nova Scotia."—By WILLIAM P. FRASER M. A., Pictou Academy, Pictou, N. S, Read by title. (See Transactions, p. 313).

(2) "The Action of Organo-metallic Halides on Quinone."—By C. C. WALLACE, B. A., Dalhousie University. Read by title. (See Transactions, p. 301).

(3) "A Possible Change in the Concentration of Solutions due to Gravity."—By HAROLD S. DAVIS, B. A., Dalhousie University. (See Transactions, p. 291).

(4) "The Occurrence of Opal near New Ross, Lunenburg County, N. S."—By HARRY PIERS, curator of the Provincial Museum. (See Transactions, p. 446).

The papers read were discussed by those present, and a vote of thanks presented to the non-member, MR. DAVIS.

HARRY PIERS,
Recording Secretary.

TRANSACTIONS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1906-1907.

THE INFLUENCE OF RADIUM ON THE DECOMPOSITION OF HYDRIODIC ACID.*—H. JERMAIN M. CREIGHTON, M. A. Dalhousie University, Halifax, N. S.

(Communicated by Dr. E. Mackay. 25th October, 1907.)

The first mention of the influence of radiant energy of any kind on chemical reactions was made by William Cruickshanks[1], who observed that hydrogen and chlorine combine under the influence of light. This particular reaction has been the source of many investigations, carried out by such men as Dalton[2], Draper[3], Bunsen and Roscoe, and, very recently, Mellor[4], Bevan[5], and Burgess and Chapman[6]. Of the numerous reactions affected by light, the following are some of the more important :—influence of light on silver salts, on the action of bromine and chlorine on metallic silver, on dyed colours, on enzymes in oxygen and hydrogen, on glass, on the oxidation of iodoform, action of oxygen on carbon bisulphide under the influence of light, the decomposition of hydrogen peroxide by light, effect of light on the combination of hydrogen and bromine, and the reaction between chlorine and benzene in the light.

*Contributions from the Science Laboratories of Dalhousie University—[Chemistry]. Printed in advance in present part by permission of the Council of the Institute.

1. Nicholson's Jour., 1801, (1), 5, 202.
2. A New System of Chem. Phil., p. 300.
3. Phil. Mag., 1844, (iii), 25, 9: 1845, (iii), 26, 473.
4. Journ. Chem. Soc., 1904, 53.
5. Proc. Camb. Phil. Soc., 1902, (ii), 264-266.
6. Jour. Chem. Soc., 1906, 88, 1399.

Other forms of radiant energy whose effects on chemical action have been investigated are ultra violet light, Röntgen rays and radium radiations.

Only a comparatively small amount of work has been carried out on the effect of radium on chemical reactions. Hardy and Wilcocks[1] have investigated the oxidation of iodoform when acted on by Röntgen rays and by radium, and Hardy[2] has observed the coagulation of globulin under the influence of the latter. Becquerel[3] found that white phosphorus is changed into the inactive red phosphorus, and that mercuric chloride in the presence of oxalic acid is reduced to mercurous chloride by the radiations from radium. The Curies[4] have shown that the rays from radium change oxygen into ozone and discolour glass. Berthelot[5] cites the following cases: iodic acid is decomposed by radium rays and by light, with liberation of iodine, this change being much slower than that of iodoform; nitric acid gives off nitrous fumes when acted on by radium rays and by light. These, as far as I have been able to discover, are all the reactions that have been investigated up to the present time.

These investigations have been mainly of a qualitative nature, the quantitative side receiving very little attention. The following experiments were carried on with a view to finding out whether a quantitative examination of the change, if any, produced in hydriodic acid by the presence of radium would throw light on the part played by the rays in this decomposition. Hydriodic acid was chosen on account of its instability; and from its behaviour under the influence of light, it was believed that it would be affected by radium rays.

The effect of light on the decomposition of hydriodic acid has, in the last few years, been largely investigated. Pinnow[6],

1. Proc. Roy. Soc., 72, 480, 200.
2. Proc. Phys. Soc., 1903, May 16.
3. C. R., 1901, 133, p. 709.
4. C. R., 1899, 129, p. 823.
5. C. R., 1901, 133, p. 659.
6 Ber. d. deut Chem. Ges., 1901, 34, 2528.

who has done a lot of this work, used acid solutions of potassium iodide for the production of hydriodic acid. He found that the best results are obtained when the solution of potassium iodide used has a concentration of 1 gram per litre. It was a solution of this strength that was used in all the following work. The hydriodic acid was set free from the iodide by a solution of sulphuric acid consisting of one part of acid (sp. g. 1.84) to five parts of water. The proportion of acid to iodide solution was one to eight.

The amount of oxidation was determined in the usual way, by titrating the liberated iodine with $\frac{N}{1250}$ sodium thiosulphate solution.

It was found that the end point could be determined very quickly and accurately by highly illuminating the solution by means of an electric light placed behind it, and reflecting back the rays through the solution by placing a piece of white paper around the beaker on the opposite side.

The potassium iodide used was the chemically pure guaranteed reagent supplied by C. F. Kahlbaum.

By carrying out the titration in the above manner, the error was found to be about $\pm$ 0.08 cc. sodium thiosulphate solution.

Five milligrammes of radium bromide of activity of about 1,000,000 were employed. The radium was enclosed in a small glass tube, so that only the β and γ rays were used.

The starting point in the investigation was to determine whether radium exerted any influence on the oxidation of hydriodic acid. For this purpose, the radium was placed over a vessel containing the acid solution of potassium iodide, of the concentration mentioned above, and allowed to bombard the solution for a certain time; at the end of that time the amount of decomposition was compared with that of a similar solution that had not been acted upon by radium. The vessels used to contain the solutions were ordinary wide-mouthed reagent bottles, with a capacity of about 125 cc. The small glass tube

containing the radium was held in the end of a hollow brass rod, which was placed in a fixed position in a wooden block; this latter fitted into the mouth of one of the bottles Thus, by filling the bottle to a definite mark, the distance between the radium and the surface of the liquid was always kept the same. This distance was between two and three millimeters.

These experiments were all carried out in a photographic dark room, so that there was no chance of the reaction being influenced by light. The solution which was not to be acted on by radium was protected from the rays by a screen of lead, so placed that the solution would not be affected appreciably by the secondary rays set up in the lead.

Several experiments carried out in this way showed, at the end of twenty-four hours, that the decomposition in the solution acted upon by radium was greater than the decomposition in the other; but the excess varied in different trials from 15 per cent to 25 per cent. In order to obtain more concordant results for similar experiments, the temperature at which the reaction took place was kept constant for a series of measurements and it was found that this made a decided improvement in the agreement of the results. It was still found, however, that the differences in results under similar conditions were considerably greater than those due to experimental error. In order to see whether these differences were due to small errors in the mixing of the solutions, a large quantity of solution was prepared and divided into six equal parts of 225 cc. each. These were allowed to stand for twenty hours in the dark room, without radium, at a temperature of $16 \pm 0^{\circ}.5C$. At the end of that time the amount of decomposition, as measured by the number of cc. of titrating solution required, was found to be for the several portions, 5.38, 5.23, 5.41, 5.34, 5.07, 5.33, respectively. The lack of equality of these numbers shows that the irregularity is not to be accounted for in this way.

The influence of the impurities in the ordinary distilled water used in making up the solution was next investigated,

and it was found that when the water had a conductivity of 2.0×10^{-6} or less, at 18°C., expressed in Kohlrausch's unit (ohm^{-1}, cm^{-1})[1], the agreement between the amounts of decomposition of several similar solutions was within the limits of experimental error.

The water used in the following experiments was prepared according to the method of Jones and Mackay[2]. The ordinary distilled water was doubly distilled. The steam from the first flask, which contained the water mixed with an alkaline solution of potassium permanganate, was bubbled through an acid solution of potassium bichromate in a second flask. Into the neck of the latter flask was thrust a block-tin condenser, and held there by means of a cork made of a mixture of plaster of Paris and asbestos. The water thus obtained has a mean conductivity of 1.6×10^{-6} at 18°C. It was kept in bottles which had been used several years for that purpose.

It was found that the purity of the water, as determined by the conductivity, played an important part in the rate of decomposition of the solution. The table below shows the results obtained when using water of two different grades of purity in the preparation of the solutions.

In this table, and all those that follow, the numbers given denote the amount of $\frac{1}{1250}$ normal sodium thiosulphate solution required to titrate the free iodine content in the hydriodic acid solution at the specified times after the instant of mixing. The mixing was done in the dark room. In all cases the amount of hydriodic acid solution experimented upon was 50 cc.

The numbers in the following table are for the case where the mixture was left to stand in the dark room, and was not subjected to the action of radium or any other external action. The temperature was $15 \pm 0°.5$C.

1. Kohlrausch und Holborn: Leitvermögen der Elektrolyte, 1898, p. 1.
2. Zeit. phys. Chem., 1897, 22, 237.

TABLE I.

Time in hours.	No. of cc. of $\frac{N}{1250}$ $Na_2S_2O_3$ solution required in titration when hydriodic acid solutions were made up with	
	Water of conductivity 4.98×10^{-6}.	Water of conductivity 2.16×10^{-6}.
7	0.73	0.90
11	0.97	1.04
15	1.38	1.40
20	1.68	1.63
25	2.05	....
30	2.45	1.79
35	2.80	...
40	2.86	1.95
50	3.20	....
70	4.05	...
95	4.37	3.08
120	4.25	3.35
170	3.75	3.24
200	3.24	3.24
300	3.45	3.22
380	1.58	3.23
450	....	3.21
550	....	3.25
650	0.89	3.20
1100	....	3.24

From an examination of this table it will be seen that there is a striking difference between the behaviour of solutions made up with ordinary distilled water, and with water which has been more carefully purified. For the less pure water the content of free iodine rises to a maximum in about four days, and then gradually falls off again; but with the purer water the iodine content increases with the time for the first five days and then remains constant for the next six weeks during which

it was under observation. Similar hydriodic acid solutions made up with the less pure water were subjected to the influence of sunlight, and in that case also the iodine increases at first, reaches a maximum after some days, and finally disappears. Hence the effect of impure water is of the same nature whether the solution be left in the dark or acted on by the sunlight. It will be seen later that in certain circumstances radium has the same effect on solutions made up with pure water.

It would seem that the effect of the small amount of impurity in the water is to cause the iodine, by some sort of catalytic action to change into a third iodine product in addition to the hydriodic acid and free iodine, which alone we might at first expect. In the case of solutions made up with the purer water, where the iodine content tends towards a constant asymptotic value, as given in the third column of the above table the simplest explanation is that a third product is not being formed, and that we have there the ordinary equilibrium between the hydriodic acid, the hydrogen and the iodine. If the third product is still being formed, two suggestions present themselves to account for the continued constancy of the amount of free iodine present: (1) that the rate of formation of the third product is very small, but that in time the numbers in the last column of the table would begin to decrease also; (2) that the whole system reaches a state of equilibrium, and the iodine content will be constant however long the time. The former suggestion is the more probable one, since it is likely that by a more careful distillation of the water we have not got rid entirely of the cause of the trouble, but only reduced it in amount.

This, however, is not the only effect of the impurity in the water; it also accelerates the rate of accumulation of iodine. This is evident from the fact that the maximum value reached in the case of the less pure water is greater than the asymptotic value approached in the case of the more pure sample. As it

was found that the rate of production of free iodine was much affected by temperature, it was felt that an answer to the question of whether radium radiations had a specific action of their own on hydriodic acid, or only changed in degree the action going on in their absence, was to be looked for from a study of the action at different temperatures both with and without the presence of radium. Further efforts at an explanation of what is the action of external agencies such as impurity, light, Becquerel rays, etc., will therefore be deferred until the experiments on the effect of temperature on solutions with and without radium have been detailed.

The following table contains the results obtained with water of a high degree of purity at a temperature of 24° C., both with and without radium. A new sample of 50 cc. of hydriodic acid solution was taken for each period of time shown.

TABLE II.

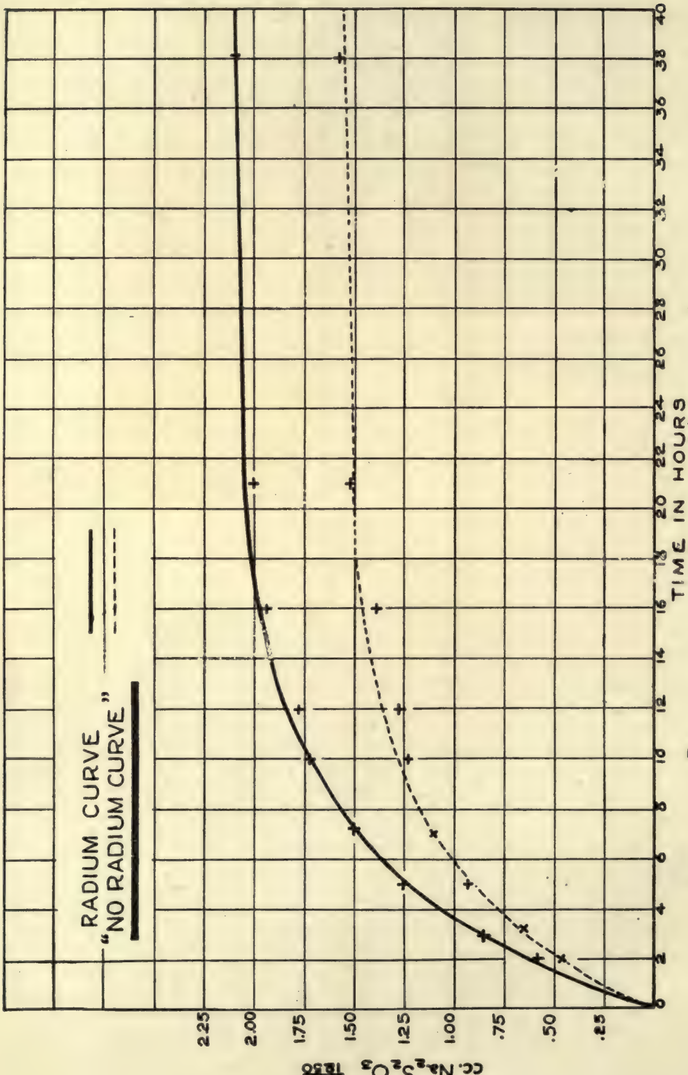
Time in hours.	No. of cc. of $\frac{N}{1250}$ $Na_2 S_2 O_3$ solution required in titration when decomposition of hydriodic acid solution takes place in the dark in the presence of			
	No radium.		Radium.	
	Observed y	Calculated from $y = a(1 - e^{-bt})$ $a = 1.54$, $b = 0.175$	Observed y	Calculated from $y = a(1 - e^{-bt})$ $a = 2.10$, $b = 0.175$
2	0.45	0.45	0.58	0.62
3	0.65	0.63	0.85	0.86
5	0.92	0.90	1.25	1.23
7	1.10	1.09	1.51	1.48
10	1.23	1.27	1.73	1.73
12	1.27	1.35	1.77	1.85
16	1.38	1.45	1.94	1.98
21	1.52	1.50	2.01	2.05
38	1.56	1.54	2.09	2.10

In the third and fifth columns of Table II. are added numbers calculated from the equation

$$y = a\ (1 - e^{-bt})$$

with the values of a and b there given, to show how well the observations are represented by curves of this type. These calculated curves are plotted in figure (1), the amounts of sodium thiosulphate solution being represented as abscissae. The observed values are marked and lie remarkably well on the curves. The similarity of these two curves seems to show that with pure water, at this temperature, the action of radium is of the same nature as that which goes on without it in the dark, but is greater.

FIG. I.



Decomposition of Hydriodic Acid at 24° C

If now, in t' e reaction under investigation, we assume that the hydriodic acid breaks down into iodine, and that this in turn breaks down into a third substance, then we have a case which is similar to the successive changes which take place in the break down of radium. Rutherford[1] has shown that if in such a change as this n is the amount of any substance A, in this case hydriodic acid, initially present, then the amount of B, in this case free iodine, at any time is given by the equation

$$y = \frac{n\lambda_1}{\lambda_1 - \lambda_2} (e^{-\lambda_2 t} - e^{-\lambda_1 t}) \ldots\ldots\ldots\ldots\ldots (1)$$

where λ_1 and λ_2 represent the rates of change of A into B and of B into C, respectively, where C is the third product.

Assuming that this third product is formed, there seem to be three probable ways in which the radium may act.

(1) The production of iodine is accelerated and also the production of the new product into which the iodine is changed.

(2) The production of iodine is unaffected, but that of the third product retarded.

(3) The production of the iodine is accelerated, while the production of the third product is retarded.

Of these three cases the two latter seem to be the least probable.

Let us apply equation (1) to the results of observation at 24°C. If the second change is very slow or zero, that is, if λ_2 is negligible, the amount of free iodine at the end of time t would be given by the equation

$$y = n\ (1 - e^{-\lambda_1 t}) \ldots\ \ldots\ldots\ldots\ldots (2)$$

Solving this equation for λ_1, we get

$$\lambda = \frac{\log\ n - \log\ (n-y)}{t\ \log_{10} e} \ldots\ldots\ \ldots\ldots (3)$$

Substituting in this equation values of t and y obtained from columns 1, 2, and 4 of Table II, we derive for λ values which show a very satisfactory agreement, as is seen in the following table:

1. "Radioactivity," p. 332.

TABLE III.

Time in hours.	No radium curve $.n = 1\ 54$		Radium curve $.n = 2.10$	
	Amt. $Na_2\,S_2\,O_3$ y	Rate of change. λ	Amt. $Na_2\,S_2\,O_3$ y	Rate of change. λ
2	0.45	0.173	0.58	0.162
3	0.65	0.183	0.85	0.173
5	0.92	0.182	1.25	0.181
7	1.10	0.719	1.51	0.181
10	1.23	0.160	1.73	0.174

This justifies us in supposing that at 24°C., both with and without radium, there is no third product being formed from the iodine; and the numbers given in columns three and five of Table II were calculated from equation (2). As was pointed out before, the action of radium serves merely to accelerate the action which goes on in its absence.

In order to see if more light would be thrown on the action of the radium the decomposition of hydriodic acid was observed at other temperatures.

The reaction was next observed at 12°C., and the results are given in the following table :

TABLE IV.

Time in hours.	No. of cc. of $\frac{N}{1250}\,Na_2\,S_2\,O_3$ solution required in titration when the decomposition of hydriodic acid takes place in the dark in the presence of			
	No radium.		Radium	
	Observed y	Calculated from $y = a\ (1-e^{-bt})$ $a = 1\ 92, b = 0.07$	Observed y	Calculated from $y = a\ (1-e^{-bt})$ $a = 2.90, b = 0.07$
2.5	0.30	0.31	0.49	0.46
8.0	0.75	0.83	1.15	1.25
10.0	0.95	0.96	1.43	1.46
18.0	1.47	1.37	2.15	2.08
30.0	1.69	1.69	2.55	2.55

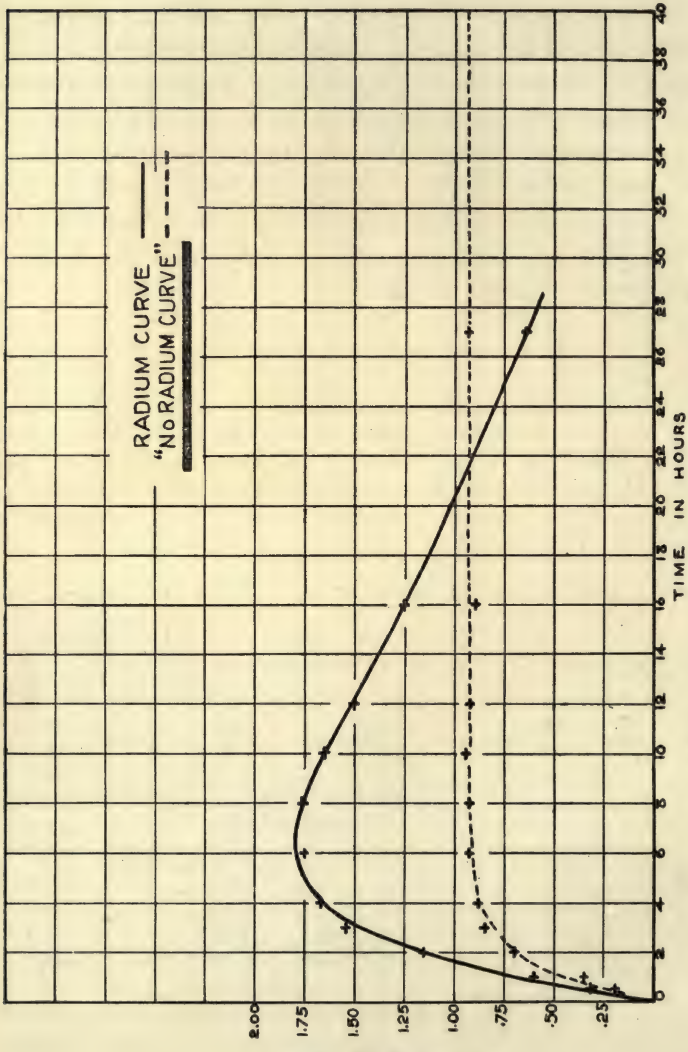
The curves for these numbers are similar in form to those for 24°C. The only difference between the behaviour at this temperature and that at 24°C. is that at the former the decomposition of the solution is much slower, and the equilibrium values consequently much longer in being reached. The effect of radium is again apparently only to increase the action in degree, but not to change it in type. Here, too, as at 24°C., there is probably no third product being formed from the iodine. The reaction was next observed at 36°C., and the following table shows the results obtained :

TABLE V.

Time in hours.	No. of cc. of $\frac{N}{1250}$ $Na_2S_2O_3$ solution required in titration when the decomposition of hydriodic acid solution takes place in the presence of			
	No radium		Radium	
	Observed y	Calculated from $y=a\,(1-e^{-bt})$ $a=0.92$, $b=0\ 70$	Observed y	Calculated from $y=a\,(e^{-bt}-e^{-ct})$ $a=3\ 3$, $b=0.06$, $c=0.31$
0.5	0.18	0.27	0.30	0.38
1	0.35	0.46	0.60	0.69
2	0 70	0.69	1.15	1.15
3	0.85	0.81	1.50	1.46
4	0.88	0.87	1.65	1.64
6	0.93	0.91	1.75	1.79
8	0.92	0.92	1.75	1.75
10	0.93	0.92	1.65	1.64
12	0.91	0.92	1.50	1.52
16	0.90	0.92	1.25	1.24
27	0.93	0.92	0.65	0.65

The curves formed from these numbers are given in figure 2.

FIG. II.



DECOMPOSITION OF HYDRIODIC ACID AT 36°C.

At this temperature it is seen that the maximum is quickly reached in the case of the solution under the influence of the radium; and the effect due to the second reaction, the supposed changing of the iodine into a third substance, is soon noticeable. On the other hand, the curve for the solution not affected by radium resembles the curves for both radium and no radium at lower temperatures, but it would seem probable that in this case the time taken to reach the maximum is shorter. In this case also there is therefore no measurable formation of the third product. A comparison of the no radium curves for 12°, 24° and 36°C will show that with a rise in temperature the rate of decomposition of hydriodic acid increases, while the maximum amount of iodine in solution is less and the time taken to reach this maximum shorter. The same is true for the radium curves at 12° and 24°C.

If the theory previously stated of what is taking place be correct, the general equation (1) should be the equation of the radium curves for 36°C.

Rutherford[1] has shown that the smaller of the two quantities λ_1 and λ_2 is given by the latter part of the downward curve. The equation of this part of the curve is then of the form

$$y = n \cdot e^{-\lambda t} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Accordingly, from the observed values of y at 12, 16 and 27 hours, n was found to be 3.3 and λ_1 to be 0.06. By finding the differential of equation (1) with regard to time and equating it to zero, we find that the maximum occurs at a time T, given by the equation

$$\lambda_1 e^{-\lambda_1 t} = \lambda_2 e^{-\lambda_2 t} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Putting for t the value 6.6 found from the curve, and for λ_1 its value 0.06, we find λ_2 to be 0.31. The numbers calculated from equation (1) with these values of the constants are given in the last column of Table V, and the agreement with the observed values falls well within the limit of experimental error.

1. Loc. cit., p. 343.

Since for no radium at 36°C., λ_1 was found to be 0.70, and λ_2 was zero (or very small), we see from the foregoing results that the influence of the radium at this temperature is to decrease the rate of decomposition of the hydriodic acid into iodine, and to increase the second action considerably, namely the transformation of the iodine into the third compound.

It is an easy matter to determine when the amount of hydriodic acid is half gone. If n is the amount of hydriodic acid initially present and P is the amount present at any time t, then

$$P = n\ e^{-\lambda_1 t}$$

Calling T the time taken for half of the hydriodic acid to be transformed, we have

$$\tfrac{1}{2} = e^{-\lambda_1 t}$$

$$\text{whence } T = -\frac{\log_e 0.5}{\lambda_1}$$

Substituting the values of λ obtained with no radium for 24°C. and 36°C. in this equation, we find that it takes about 384 hours at the former temperature and about 17 hours at the latter for half the amount of hydriodic acid to be decomposed into iodine.

Effect of Temperature.

In order to show the effect of temperature alone, both when the solution is under the influence of radium and without it, the reaction was allowed to proceed for ten hours at various temperatures. The results were as follows :

TABLE VI.

Temperature.	No. of cc. of $\frac{N}{1250}$ $Na_2 S_2 O_3$ solution required in titration when the decomposition of hydriodic acid takes place in the dark in presence of		Difference.
	No radium.	Radium.	
0	0.20	0.78	0.58
4	0.45	1.02	0.57
8	0.68	1.21	0.53
12	0.95	1.43	0.48
16	1.20	1.73	0.53
20	1.25	1.75	0.50
24	1.23	1.73	0.50
36	0.93	1.65	0.72
	Mean of all Differences except that for 36°C. . .		0.53

If these numbers are plotted it is seen that the curves are straight lines below 16°C. If the latter are produced backward they will cut the axis of temperature at about $-12°$C. and $-3°$C. for the radium and no radium curves respectively. At these temperatures there should be no decomposition unless the curves should become asymptotic, and, considering the steepness of the curves at 0°C., this would not seem probable for the "no radium" curve at least. Of course it was out of the question to keep the solution at $-12°$C. on account of its freezing, but a solution could easily be kept at $-3°$C. for a time.

This temperature ($-3°$C.) was easily obtained by placing the solution in a bath of very dilute alcohol, which was surrounded by a mixture of salt and snow. It required but little attention to keep this bath at a temperature of about $-3°$ 6C. to $-4°$C.

It was found at the end of ten hours that the decomposition in a solution not under the influence of radium, and kept at a temperature of $-3°$C. during that time, was equivalent to 0.19 cc. sodium thiosulphate. Hence the curves at 0°C. must cease to be straight lines, and begin to run asymptotically toward the axis of temperature.

From this work on the effect of temperature we are again led to conclude that the radium intensifies the action that is already going on.

Effect of γ Rays Alone.

Hardy and Wilcocks[1] have shown that the γ rays from radium accelerate slightly the decomposition of iodoform, but that the acceleration is small as compared with that due to the β rays. In order to determine whether the γ rays behave in the same way upon the hydriodic acid reaction, the rays from the radium were made to pass through 6 millimetres of lead before entering the solution. This thickness of lead is sufficient to absorb all but the fastest β rays, and does not appreciably absorb the γ rays. The reaction was first allowed to go on for ten hours at 24°C, when the amount of free iodine was found to be equivalent to 2.10 cc. sodium thiosulphate solution.

For the sake of comparison the results for ten hours are here grouped :

No radium for 10 hrs. at 24°C	.....1.23	cc.	$\frac{N}{1250}$	$Na_2S_2O_3$	solution
β and γ rays " "	....1.73	"	"	"	"
γ rays " "	....2.10	"	"	"	"

At first this result seems to disagree with that obtained by Hardy and Wilcocks. Indeed it does not seem reasonable that the γ rays, whose energy is much less than that of the β rays, should accelerate the decomposition more than the latter. Closer consideration, however shows that the disagreement is only apparent and that the result is in accordance with the above theory of the break down of hydriodic acid.

For if, as we have supposed, there are two successive reactions taking place, both of which are accelerated by the influence of radium, then since it has been shown that the second one of these is the more influenced, it is quite probable that when the energetic β rays are absorbed and not allowed to enter the solution, the second reaction is relatively retarded, and so we have the amount of free iodine in the solution increased. If this is what is happening, then for a few hours after the

1. Loc. cit.

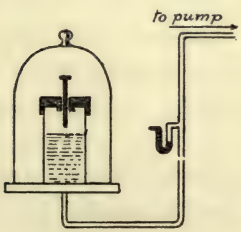
beginning of the reaction, before the second reaction begins to make itself felt, we should expect to find that the amount of iodine set free is less when the solution is acted upon by γ rays, than when it is acted upon by β and γ rays. At the end of three hours, when the solution had been kept at 24°C., the decomposition was found to be as follows :

No radium	for 3 hrs.	at 24°C	...0.65	cc. $\frac{N}{1250}$ $Na_2S_2O_3$ solution
β and γ rays	"	"	....0.85	" " " "
γ rays	"	"	...0.72	" " " "

Influence of Sunlight and Radium in the Absence of Oxygen.

If a hydriodic acid solution such as was used in the preceding experiments be entirely freed from occluded air, and placed in a tube from which all the air has been removed, it was found that this tube could be placed in the sunlight for any length of time, without the solution showing any decomposition. In order to remove all occluded air before being sealed off, the solution was kept in a vacuum in the dark for twenty-four hours ; for otherwise it is found that extremely minute quantities of dissolved air will slightly decompose the hydriodic acid.

The same experiment was then tried with radium, instead of sunlight. In order to keep the solution under a vacuum for two or three days, without sealing up the radium in a tube with the solution, the vessel containing the solution with the radium was placed under a bell jar on a brass plate, connected by a glass tube to a " Geryk " vacuum pump. The joint between the



bell jar and the brass plate was made perfectly tight by sealing it with a preparation made by heating together equal parts of pure india rubber, paraffin, and vaseline. When the vacuum was made this tube was sealed off from the pump. A delicate manometer connected with the jar, showed no change

in vacuum at the end of several days. It was found that the radium also produced no effect. The experiment was tried at room temperature only.

Summary.

1. When prepared with very pure water a hydriodic acid solution decomposes in the dark, reaching an equilibrium value. (Experiments made up to 36°C.)

2. Ordinary distilled water contains impurities producing some catalytic action which accelerates the decomposition of hydriodic acid solution in the dark, at the same time introducing another reaction, which causes the amount of free iodine to reach a maximum value and then fall off indefinitely. (Experiments made at 15°C. only.)

3. At any temperature up to 24°C, more iodine is liberated in a given time from a solution of hydriodic acid in the dark, under the influence of radium, than from one that is not so influenced.

4. When the experiment is tried at 36°C. this last statement is only true up to 24 hours; for whereas the amount of free iodine with no radium reaches an equilibrium value, with radium it reaches a maximum and then falls off indefinitely.

5. At 36°C. radium seems to cause the formation of the same third product which impurity in water produces at low temperature.

6. In general, increase of temperature tends to increase the amount of free iodine at any time, whether radium is used or not.

7. The γ rays alone cause more iodine to be free than do the β and γ rays together. (Experiments made at 24°C. only.)

8. Neither sunlight nor radium causes decomposition of hydriodic acid solution in absence of oxygen. (Experiment made at room temperature only.)

I wish, in conclusion, to thank Professors Mackay and Mackenzie, for their kind suggestions and criticisms during the progress of this work.

Dalhousie University, June 1st, 1907.

Water Power of Halifax County, Nova Scotia: Part I, Dartmouth Lakes Power.—By F. W. W. Doane, C. E., City Engineer, Halifax.

(Read 13th May, 1907.)

It is not the purpose of this paper to present any novel or improved ideas in hydraulics or hydro-electric power, but first to call attention to the undeveloped possibilities in our well-known water courses, and second to describe somewhat in detail the water power available from a water shed in the county of Halifax, a portion of which is partially developed, the remainder almost as nature formed it.

To the average man a water power is necessarily something with a big dam across an imposing stream. Indeed, many engineers are accustomed to look for large watersheds and high heads, overlooking entirely the possibilities of the small streams. In the House of Assembly a short time ago, it was stated that there are no water powers in Nova Scotia worthy of the notice of the government. This assertion may or may not be correct, yet while all of the larger powers have been discovered, and many of them harnessed, there still remain many falls on our streams which have escaped notice or have been considered too unimportant to develop. Many hydraulic powers are in use, but are not furnishing anything like the quantity of power which they are capable of developing.

The board of trade last year, in a quarterly report, regretted the lack of cheap powers for industries in Halifax, but went no farther in a search for a remedy. Mr. Yorston, in his paper read before the Institute last year, stated fully the possibilities of the power on the Mersey River in Queens County. A portion of the dormant power in the Gaspereau Valley is being developed for transmission to the neighboring

towns, Wolfville and Kentville, while the latent energy of the tides of the Bay of Fundy still await the master hand of the engineer, the promoter, and the capitalist.

With the rapid growth of the demand for power, and the necessity for obtaining that power as cheaply as possible, we can no longer afford to ignore the possibilities of the minor hydraulic powers, many of which are yet undeveloped, while others now in use are not developed to their full capacitv.

We have no mountain streams with great heads in Halifax County, but there are many streams which contain possibilities which would justify investigation at least.

At twenty feet head it takes a wheel a couple of feet in diameter and a flow of about 3,500 cubic feet of water ner minute to give 100 horse-power. At eighty feet head a 10-inch wheel will do the same work on one-quarter of the quantity of water, while with a very high head a mere brook may suffice to give a power that may be worth at least developing for local use.

Minor powers are not uncommon in any hillv district, but the small flow diverts attention from them. Yet this very class may have possibilities in the way of storage of water that would make them most attractive. In some cases where a number of square miles of watershed are available, it may be possible by the construction of dams to form storage lakes or increase the capacity of existing natural reservoirs, and by this means create a useful power where only a moderate stream flowed before.

There is, of course, a limit to the minimum quantity of continuous water power that is worth considering, whether for local use or in connection with electric transmission. The governing features of the problem are the general cost of development and equipment, the cost of transmission, and the cost of operation.

In hydraulic work the cost of conduits from the dam to the power house is generally the controlling item, and this is again determined by the distance necessary to be covered and the available flow.

If the cost can be kept in the neighborhood of $100 per horse-power, the outlook for an economical short transmission is good, since this means an annual charge of no more than $10 or $12 per horse-power for the motive power. The cost of wheels and generators with their equipment will run generally from $25 to $30 per kilowatt in cases where raising transformers are not needed, the usual case for small powers. All of this can be approximated very readily, as also can the cost of the necessary buildings.

The heaviest charges in small work come in the operating expenses and in the pole line. Pole lines for light wires need not cost more than $250 to $300 per mile, exclusive of wires and right-of-way. The latter, in working on a small scale, is commonly along the highway, so that the cost is small; but the cost of wire, unless the line is short, may add considerably. Still, at a given voltage, the cost of copper per kilowatt transmitted is a constant, and the only relatively fixed item is the cost of stringing, which varies only slightly with the size of wire until the larger sizes are involved. For mechanical reasons, however, it is not desirable to string wire smaller than No. 4 or No. 5, so that the minimum cost of conductor is somewhere about $500 per mile. Fortunately, the depreciation charge against bare wire is practically negligable, and wire of this minimum size will carry comfortably the output of the class of plant considered.

In hydro-electric plants the operating expense is largely one of fixed charge, while with steam plants it is made up of fixed charges coupled with variable items of coal, water, oil, waste and incidentals. With the hydro-electric plant, consequently the cost per horse-power per year is almost constant, regardless of whether supplied one hour a day or twenty-four hours a day. Repairs are about the only variable, and they may be considered as increasing in direct proportion to the load factor. Labor, oil, waste, etc., are nearly the same, irrespective of the proportion

of light loads to full loads. With the steam plant, on the contrary, the items of coal, labor, etc., increase rapidly with the load factor, and hence the cost per horse-power per annum increases in almost the same proportion.

The cost of attendance is the most serious outlay in small stations. It means, generally, the pay of at least three men, and occasional extras—not less than $2,000 per annum, even for a very small plant. At 100 kilowatt capacity this would come to at least $20 per kilowatt per year, which added to the other charges, is pretty nearly prohibitive. At 200 kilowatt capacity, the operating charge gets down to reasonable figures. In a rough estimate, one will not go far wrong in saying that for electrical purposes a water power of 250 to 300 horse-power on steady flow is worth considering. Anything below this is of little account, except for local utilization, and the usefulness of the power increases rapidly above this point.

If the situation is favorable for storage, a good deal can be done with small streams; but unless the above amount can be made available without going to heavy expense, there is not much that can be done. If two or more such powers are available they can be often worked together to advantage. There are powers near the limiting size that have been passd over as too small, and these are the ones which ought to be carefully looked after in the interest of small places and small industries.

The fundamental fact that faces the engineer of a hydro-electric plant is that the total amount of hydraulic power available is, once for all, a fixed quantity. Of the rain that falls in the drainage area of the stream a certain proportion finds its way into the stream and that is all that is there available. Taking a series of years, too, the distribution of this available water through the year is approximately uniform, so that one can state broadly the total normal power per year, and that its distribution through the year follows a certain power curve. In some streams this curve is very regular, in others extremely

irregular, showing torrents at certain seasons and rivulets at others. The task of the engineer is to take the power curve and do with it the best he can in earnings, attacking the problem with all the resource at his command.

No hydro-electric plant of limited capacity should be studied at the present time without considering the use of auxiliary power. Oftentimes such a study would result in the rejection of auxiliaries altogether. At other times, after all has been done that is possible in obtaining the best available storage, there may remain a feature of the problem which may be economically handled only by steam or gas auxiliaries. But a short time ago, the presence in any hydro-electric system of steam or gas auxiliaries, was considered a confession of weakness in the hydraulic system. Fortunately this false idea is fast losing ground, and it is recognized that the best of engineering is shewn by their use, and in consequence, hydro-electric opportunities are being utilized which were previously neglected.

Streams of comparatively constant flow, by the installation of steam or gas auxiliaries, are enabled to supply heavier loads than would be otherwise possible, though perhaps the most important use for auxiliaries is found in cases where the normal stream flow is very materially reduced during short periods of the year, by reason of special conditions in the watershed.

It is not reasonable to develop a hydro-electric station when a steam or gas station could be built which would supply the same territory at a lower cost, but it is also unwise to condemn a hydro-electric development because the cost per unit of capacity is high, when at the same time it can develop cheaper power than can be done in any other manner.

In the province of Ontario, the government has appointed a hydro-electric power commission, whose duty it is to develop and supply electric energy not only to municipalities requesting it, but also to any railway or to a private company distributing electricity.

In the annual report of the New York state water supply commission, that body strongly urges the state control of waters. This refers not only to such a regular examination of water supplies for potable purposes as shall insure the detection of any serious change in their quality, but also to the larger problem of the regulation of stream flow in order to prevent floods. The commission believes that it is unwise to allow the appropriation of potable waters for power purposes, except under such state supervision and regulation as is at present exercised in the case of water-works plants. The diminution of floods, the report states, could be brought about by the construction of reservoirs which need not flood public forests, an act prohibited by the constitution, and the waters stored in these reservoirs might be made a source of revenue. The portions of the report recently made public do not reveal any definite plans for legislation to carry out the suggestion, but the general proposition that the state should exercise an equitable supervision and control over the unappropriated waters of the state meets with public approval. The time is coming quickly when water powers and water supplies will be appraised much higher than now, and any failure to secure state control of them, so far as they are now unappropriated, may be unfortunate.

It is becoming daily more and more apparent that the coal mines, steamers and railroads cannot supply a permanent and continuous generation of power so readily as the rivers. The experience of the past has brought this home to all classes and sections of the Dominion, till in some parts of the country we are now appealing to our courts and legislative bodies to relieve us from the perils of fuel famine. These conditions are but the natural outgrowth of a national improvidence which in the past has consumed our store of domestic fuel for power purposes and has allowed to run to waste the easily available power resources of the water which constantly falls upon our hills, and will continue to fall while the earth is habitable.

Cheapness of power has long ago been demonstrated for the hydro-electric plant and transmission line; reliability is now being proved. The duplicate line has already become an established factor in the system, and attention has been turned to the duplicate plant as well. The advantages of the duplicate source will be the next study.

Not only is the unreliability in the supply of coal aiding in the development of hydro-electric projects, but the price also is exercising a great influence. We do not have to go far afield to hear tales of scarcity of fuel and closed plants in consequence of strikes, car famine, etc., and every consumer of coal knows that there has been a permanent increase of about 50 per cent. in the cost. This price will not be reduced, but in all probability will continue to advance, so that it may be claimed that the hydro-electric plant, which will begin by paying expenses, must necessarily become a source of profit in the near future.

Water Power of the Dartmouth Lakes.

The nearest water power to the city of Halifax is that owned by the Starr Manufacturing Company, in Dartmouth. Until very recently this power was not controlled entirely by one company. By the amalgamation of the Starr Company and the Dartmouth Rolling Mills Company, the whole water power becomes the property of the new company, and it is now possible to develop it to its full capacity.

The drainage area from which this power is obtained includes the watershed and water surface of five lakes. Beginning at a divide a short distance south of Cranberry Lake, which lies on the south side of the Preston Road, about three and one-half miles east of Dartmouth, the surface slopes northwardly and westwardly. Cranberry Lake empties by a stream about one-third of a mile in length, crossing the Preston Road into Lake Loon, which in turn drains into Lake Charles, about one mile and one-half westwardly as the crow flies. From Lake

Charles the surface slopes both northwardly and southwardly, Lake Charles being the highest of the chain of lakes utilized in the construction of the Shubenacadie Canal. While no longer needed for canal purposes, the masonry of the old locks is still in good condition, and is used by the Starr Company in connection with their storage dams.

When the lakes are overflowing, Lake Charles has an outlet at both ends, but except in time of freshet, the outlet is southwardly into Second Dartmouth Lake. The stream between Lake Charles and Second Dartmouth Lake is about seven-eighths of a mile in length, and passes through two of the old locks. From Second Dartmouth Lake the water flows directly into First Dartmouth Lake. From the latter, it is let down through Sullivan's Pond as it is required. Penhorn Lake, lying south of the Preston Road, about a mile and a half east of Dartmouth, drains into the Second Lake. Oathill Lake, situated about three-quarters of a mile eastwardly from the town, and south of the Preston Road, empties into First Lake.

From a map in the possession of the Deputy-Commissioner of Public Works and Mines, the areas have been obtained as follows:—

Lake Loon watershed	840	acres.	
Lake Charles watershed	3400	"	
First and Second Lakes watershed	3060	"	
Total area of lakes and watershed	7300	"	= 11.4 sq. miles

Lakes only:

Cranberry Lake	23	acres.	
Loon Lake	190	"	
Reservoir below Loon Lake	23	"	
Lake Charles	337	"	
First and Second Lakes	441	"	
Other lakes	36	"	
Area of lakes	1050	"	= 1.6 sq. miles
Area of watershed, not including lakes	6250	"	= 9.8 sq. miles

The country is rough and broken, a portion being wooded, and a large proportion waste land.

After passing through the Starr Manufacturing Company's works, the water, previous to the amalgamation of the two companies, was used again at the electric light station below Portland Street.

For this purpose the water was carried to a point opposite the light station by a flume 4 ft. 6 in. wide, and 15 in. deep. When examined by the writer the water was flowing about 14 in. deep with an inclination of .002 feet per foot. Under those conditions the sluice would discharge 1134 cubic feet per minute. From the flume the water was taken by a 4 ft. pipe to a 20 in. crocker turbine, working under a head of 18 ft. 4 in. At 75 per cent. efficiency the wheel would develop 29.25 horse-power.

The water running the Starr works is drawn from Sullivan's Pond through a 44 in. pipe, 417 feet long, with a discharging capacity of 12,900 cu. ft. per minute. The wheels work under 31 ft. head. The shop is run by a 30 in. wheel, "standard" make, purchased from T. H. Risdon & Co., Mount Holly, New Jersey. The grinding room machinery is kept in motion by a 10 in. "American" turbine manufactured by the Dayton Globe Iron Works Co., Dayton, Ohio. A 22 in. "special" new American turbine (Dayton make) has been used to operate electric generators for lighting the town.

The catalogue capacity of these wheels is:—

Size	Head in ft.	Revolutions.	Horse-power.	Cu. ft. of water used.
30 in.	31	262	83.4	1674
10 in.	31	681	21.8	465
22 in.	31	326	116.7	2492

A comparison with the theoretical horse-power of the water used shows that the wheels are rated at higher efficiency than

they can reach in practical work. The large wheel is rated at 85 per cent. efficiency and the other two at 80 per cent.

At 75 per cent.	efficiency	1674	cu. ft.	at 31	ft. head	=	73.5	horse-power.
75	"	"	465	"	31	"	=	20.25	"
75	"	"	2492	"	31	"	=	109.5	"

The Starr Company was under contract to supply power to the Electric Light Company up to 100 horse-power from sunset to midnight, and 30 horse-power from midnight to dawn. It is estimated, therefore, that the average quantity of water consumed per day in developing power was:—

1674						
465						
2139	cu. ft.	per minute	x 60 x 9 hours	= 1 153,560	cu. ft.	per day.
2492	"	"	x 60 x 6 "	= 897,120	"	"
1134	"	"	x 60 x 5 "	= 2,390,880	"	"

This quantity used at an equal hourly rate for twenty-four hours would produce 73 horse-power at 75 per cent. efficiency. Adding the 29.25 horse-power developed below, the total 24-hour power would be 99.25 horse-power. For nine hours it would produce 195+29.25=224.25 horse-power.

Assuming for the present that the quantity of water used daily is correct, it is not developing the total horse-power that it is capable of producing. If, instead of the present system, all of the water were carried in a pipe from Sullivan's Pond to a wheel at the electric light station, there would be a head of at least fifty feet. The above quantity of water would then develop at 75 per cent. efficiency, 116.75 horse-power for twenty-four hours, or 314.25 horse-power for nine hours. The nine-hour power would be an increase of 90 horse-power, or 40 per cent. In order to obtain this additional power it would be necessary to convert the hydraulic plant now running the Starr works into a hydro-electric plant.

The same water used for power at the Starr works is available for the development of power at the foot of First Lake, as Sul-

livan's Pond, through which water is drawn from First Lake for the Starr Company's plant, is comparatively very small, and has practically no watershed. When First Lake is full, there is a head of about twelve feet above Sullivan's Pond. Assuming that First Lake can be maintained at overflow level every day of the year, and that the quantity hereinbefore estimated is available, a wheel at the canal lock would develop at 75 per cent. efficiency, 28 horse-power for 24 hours, or 77.5 horse-power for 9 hours. If Sullivan's Pond could be raised 12 feet, this additional power would be available at the Starr works without electric transmission.

The quantity of power that could be taken from the estimated available water by carrying it in a pipe from First Lake to a wheel at high-water mark would not be greater than that developed by a wheel at the Canal lock at the foot of First Lake, and another at high-water mark, operated by water drawn from Sullivan's Pond. The total would be about 390 horse power for 9 hours, or 145 hore-power for 24 hours.

The fall in the stream from Lake Charles to Second Lake affords another opportunity to increase the total capacity of this power. This portion of the old canal is known as Port Wallis Locks. The upper lock gate is closed, and holds the water up to the level of Lake Charles. There is a fall in the lock of about 19 feet, and at the lower lock about 10 feet. Estimating the available portion of the rainfall over the watershed draining to this point at two feet, a wheel at Port Wallis Locks would develop 25 horse-power for 24 hours or 66 horse-power for 9 hours.

The quantity of water available, depending not only on the rainfall but on the possibility of storage, it is of the greatest importance to know what can be done to hold the water draining through the old canal. The writer is not familiar with Lake Loon, and has had no opportunity to ascertain the storage possibilities of this lake. It is stated, however, that a rise of three feet would cause the water to flow in another direction.

Lake Charles can be dammed at both ends. At the south end there is a good location for a dam. The lake could be raised six feet by a structure about 100 feet long. At the north end the dam would be from 100 to 200 yards in length. At one point on the Waverley Road the highway would have to be raised, as it is not much above the present overflow level of the lake. Raising Lake Charles six feet would increase the storage capacity about 90,000,000 feet, or about 40 days' supply for the Starr works. This additional storage would be nearly one-third of the estimated available rainfall, and there is no doubt in the mind of the writer that the storage in this power system can be increased so that the whole run-off in a dry or ordinary year can be held and used as required.

The contract with the Electric Light Company began January 1st, 1898. In 1894, which was a very dry year, the water failed, but all the wheels did not stop again for want of water until 1905, which was the dryest year on record.

In 1904 the shop ran by steam from August 5th to September 10th.

In 1904 the electric lights ran by water without stop.

In 1905 the electric lights ran by steam from September 14th to November 22nd.

In 1905 the shop ran half water, half steam, from August 29th to September 14th.

In 1905 the shop ran by steam from August 14th to Dec. 1st.

The Starr Manufacturing Company has an auxiliary steam plant, as may be inferred from the foregoing statement, which they use in case of emergency, or when once in ten years water fails. This plant affords a good illustration of the advantages of the auxiliary system, which permits a larger horse-power development on the available water than would be possible without it. In its absence the daily capacity of the plant would be reduced, and there would be danger of complete shut-down in case of accident or shortage of water.

The estimate of the quantity of water used daily at the Starr works is based on information given by the manager. If correct, the proportion of the rainfall is much larger than the usual estimate. 2,390,880 cubic feet of water every day, equals 872,671,200 cubic feet a year, which, spread over 7,300 acres, would be 33 inches, or 59 per cent. of 55,927, the average rainfall in Halifax. It is, therefore, probable that the estimated capacity is in excess of the actual capacity. The estimated capacity based on the manager's data is:—

At high-water mark (9-hour day) 365 days	314.25	h. p.	
At first lock	75 5	"	
At Port Wallis locks	66	"	
	457.75	"	
Possible nine-hour power under present development	224.25		
Possible increase	233.5	"	104 p. c.

It would be very interesting to know positively the exact quantity of water used by each wheel at the Starr works, and the exact total time run during one year, so that the run-off determined by Mr. Johnston and that at the Starr works could be compared.

A Few Chemical Changes Influenced by Radium: A New Method for the Detection of Amygdalin.*—By H. Jermain M. Creighton, M. A., Dalhousie University, Halifax, N. S.

Read 13th April, 1908.

Up to the present time only a comparatively small amount of work has been carried out on the effect of radium on chemical reactions. Hardy and Wilcocks[1] have investigated the oxidation of iodoform, when acted on by Röntgen rays and by radium, and Hardy[2] has observed the coagulation of globulin under the influence of the latter. Becquerel[3] found that white phosphorus is changed into the inactive red phosphorus, and that mercuric chloride in the presence of oxalic acid is reduced to mercurous chloride by the radiations from radium. The Curies[4] have shown that the rays from radium change oxygen into ozone and discolour glass. Berthelot[5] cites the following cases: iodic acid is decomposed by radium rays and by light, with liberation of iodine, the change being much slower than that of iodoform; nitric acid gives off nitrous fumes when acted upon by radium rays and by light. The decomposition of hydriodic acid has been observed and studied by Creighton.[6] These, as far as I have been able to discover, are all the reactions that have been investigated up to the present time.

When it had been decided to investigate what influence radium had on different chemical changes, it seemed probable that the best results would be obtained if the radium were allowed to act on the substances that were to be transformed, under the conditions most favourable to the transformation. It was mainly for these conditions that the following substances were chosen.

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*Contributions from the Science Laboratories of Dalhousie University [Chemistry.]
1 Proc. Roy. Soc., 72, 480, 200.
2 Proc. Phys. Soc., 1903, May 16.
3 C. R., 1901, 133, p. 709.
4 C. R., 1899, 129, p. 823.
5 C. R., 1901, 133, p. 659.
6 Proc. & Trans. N. S. Inst. Science, XII, 1, 1.

Five milligrammes of radium bromide of activity of about 1,000,000 were employed. The radium was enclosed in a small glass tube, so that only the α- and β-rays were used.

Action of Radium on Lead and Tin.

After a particularly cold winter, 1867-68, it was found that some blocks of tin that had been stored in the customs house at St. Petersburg, had mysteriously crumbled to a grey powder. It has since been shown that tin exists in two allotropic forms, one of which is this grey powder, the other the ordinary white malleable metal. The transition temperature of these two varieties of tin is about 20° C., the former being stable below, and the latter above this temperature. The reason all ordinary tin, most of which is at a temperature below that of transition, does not change into the grey kind, is due to its being in a state of unstable equilibrium, and kept there by an unknown agent, to which the name passive resistance has been given. If in some way this passive resistance could be overcome, then the transition of white into grey tin would readily take place.

It was in order to see whether radium would do this that the following experiment was carried out.

Two pieces of white tin, about two and a half centimetres square and a millimetre thick were prepared from pure mossy tin, and their surfaces made smooth and clean. These were placed in a small leaden box, Fig. 1, and separated from each other by means of a leaden partition, which was sufficiently thick to keep all but the fastest β-rays from passing from one compartment to the other. The ends of the box were left open. The

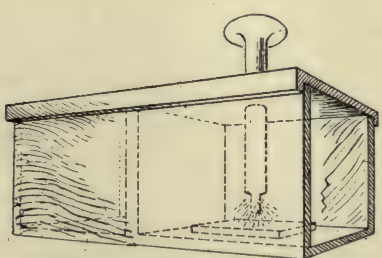

Fig. 1

small glass tube, containing the radium, was held in the end of a hollow brass rod; this latter passed through a hole in one end of the leaden cover of the box, so that the radium was over, and about a millimetre distant from, the square of tin in one of the compartments of the box. This box was placed in a large tin box and kept at a temperature of about 0°C. for four months.

At the end of that time, the pieces of tin were taken out and examined under the microscope, and it was found that there was a formation of grey tin on the surface of each, but that the amount on the piece that had been bombarded by the rays from the radium, was greater than that on the piece which had not been so acted upon. This difference, however, was not very great, but the lead box which had contained the pieces of tin, had undergone a curious change, during the four months. The inside of the compartment into which the tube containing the radium had penetrated, was completely covered, with the exception of the bottom, with a thin white film, which was present in some places, particularly the top of the box, in relatively large quantities, while the other compartment did not contain the most minute trace of this substance. Around the hole in the top of the box, where the tube containing the radium entered, the lead was coated with the white substance, much more thickly than anywhere else. Some of this powder was scraped off and analysis showed that it was lead carbonate.

The only explanation the author can give of its formation is this. Some of the rays from the radium, after striking the surface of the tin, which was probably not perfectly even, were reflected upward, and bombarded the top of the lead box and ionized it, thus making it more active than it was. The portions of the lead which were thus made active, were able to combine with the moist carbon dioxide in the air, with the production of lead carbonate. This seemed to be borne out by the fact that it was the top of the box that was most coated with the carbonate.

The Action of Radium on Hydrogen Peroxide.

The action of radium on hydrogen peroxide was next investigated, as on account of its behaviour under the influence of light,[1] it was believed that it would be affected by radium rays.

The hydrogen peroxide solution used in these experiments had a strength of 4.832 grams per litre.

Since hydrogen peroxide, when it decomposes, breaks up into water and oxygen, its decomposition can be estimated by measuring the oxygen produced, or the amount of hydrogen peroxide left in the solution by titrating with potassium permanganate. As this latter method necessitated changing the amount of substance in the system, the former was chosen, and the oxygen was measured by the change of pressure it produced.

A large reagent bottle, with a side tubulature near the bottom, was half-filled with hydrogen peroxide. Into the side neck was fitted a long graduated tube with a bend at right angles, which was to act as a pressure gauge. The brass tube containing the radium was passed through a tightly-fitting rubber cork, which was fixed firmly into the neck of the reagent bottle and so adjusted, that the radium was about three or four millimetres away from the surface of the liquid. In this way, any increase in the volume of the gas over the peroxide would produce a change in its pressure, and this change could be read by means of the pressure gauge. Figure 2 shows the apparatus.

These experiments were carried out in a photographic darkroom, so that there was no chance of the reaction being influenced by light.

[1] D'Arcy, Phil. Mag., 1902 [VI], 3, 42.

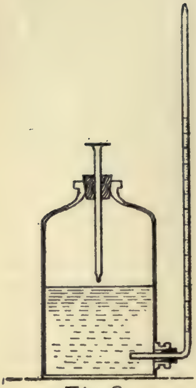
Fig 2.

360 cc. of hydrogen peroxide, of the strength mentioned above, were placed in the bottle just described, and put in the dark without being under the action of radium. The volume of gas enclosed over the liquid was 350 cc. The variations in pressure as observed by the pressure gauge were recorded for three hundred hours. After correcting this pressure for the variations due to changes of temperature and pressure, it was found that the pressure of the enclosed gas had not varied, showing that the peroxide had not suffered any decomposition during the time it was under observation.

Next an experiment was carried out, similar to that just described, except that the surface of the peroxide was bombarded by radium radiations. The increase in pressure was recorded from time to time, and the results obtained are tabulated in the following table:

TABLE I.

Time in hours.	Barometric pressure mm. Hg.	Temperature °C.	Height of liquid in manometer divisions.[1]	Increase in pressure of gas mm. Hg.	Corrected increase in pressure of gas mm. Hg.
0	761.0	19.1	145.0	....	....
7	762.01	18.8	149.9	0.5	1.7
15	762.11	18.0	157.3	1.1	4.4
30	764.10	18.8	160.2	1.4	4.1
40	763.90	19.2	165.0	2.0	2.7
50	764.01	18.0	156.0	1.0	5.8
75	761.39	17.1	151.3	0.6	6.4
100	767.11	16.6	155.5	1.0	10.9
118	764.31	16.8	163.0	1.9	10.0
142	766.01	17.9	167.0	2.2	8.4
165	764.02	18.0	162.1	1.9	6.7
200	765.13	18.0	160.1	1.4	6.8
219	764.99	18.1	158.4	1.3	6.3
238	764.41	18.1	155.0	1.0	5.6
265	760.99	19.5	163.0	1.9	0.8

[1] 20 scale divisions = 25 mm.

In the preceding table column five gives the changes in pressure of the gas in millimetres of mercury. These values have been calculated from the data in column four, the hydrogen peroxide having a density which is approximately one. Column six contains the values of column five after approximate corrections have been made for the changes due to variation in temperature and pressure; that is, these numbers represent the changes in pressure due to the increase of gas.

From these results, then, it is seen that the effect of radium on the solution of hydrogen peroxide is to decompose it. This decomposition, however, is small; for the increase in pressure corresponds only to a small increase in volume. In its behaviour towards hydrogen peroxide radium resembles light. It will be noticed that the pressure exerted by the gas, as given in the sixth column of the above table, after a time begins to decrease. The reason of this diminution in pressure will be considered later.

It is a well-known fact that the presence of finely divided solid matter or salts of the heavy metals slowly decomposes concentrated solutions of hydrogen peroxide, even at ordinary temperature. For this reason 10 cc. of $\frac{N}{10}$ solution of lead nitrate were added to 350 cc. of the dilute hydrogen peroxide used in these experiments. The addition of the lead nitrate to the peroxide caused the formation of a finely divided precipitate, the presence of which should also tend to decompose the solution. After making the necessary approximate corrections for changes in temperature and pressure, it was found that during the ten days the solution was under observation the pressure had not changed at all. Hence, it would seem that dilute solutions of hydrogen peroxide are not, or at most only exceedingly slowly, decomposed by the presence of finely divided solid matter or solution of lead nitrate.

An experiment similar to this was next carried out, with

the exception that the surface of the liquid was bombarded with radium rays. The results are given below in Table II.

TABLE II.

Time in hours.	Barometric pressure mm. Hg.	Temperature °C.	Height of liquid in manometer divisions.[1]	Increase in pressure of gas mm. Hg.	Corrected increase in pressure of gas mm. Hg.
0	759.99	20.8	142.0	....	...
9	759.90	20.8	160.5	1.7	1.7
12	759.71	21.2	167.0	2.3	1 7
15	759.41	21.4	169.5	2.5	0.8
19	758.74	21.6	165.0	2.1	0.1
23	759.21	21.8	156.5	1.4	1.5
33	759.20	21.1	141.5	0.1	1.1
36	759.30	20.6	142.8	0.1	0.4
41	759.21	19.6	136.6	0.5	2.3
48	759.41	19.1	138.0	0.4	3.9
58	759 53	17.4	95.0	4.3	4.3
63	759.91	17.4	107.0	2.3	6.3
67	760.10	17.4	108.0	3.3	5.3
73	765.31	17.4	90.0	4.8	6.3
82	767.90	16.8	89.0	4.9	9.9
87	769.18	17.6	104.0	3.5	9.0
92	767.20	18.5	123.0	0.7	9.0
100	766.17	18.0	170.0	2.6	13.2
104	764.39	18.0	208.0	6.1	15.7
109	758.55	18.0	252.5	10.1	16.7
115	754.54	18.5	305.0	14.1	17.9
120	758.52	18.4	352.5	19.3	24.9
130	758.63	18.7	483.7	31.2	36.0
136	758.63	18.7	489.2	31.8	36.6
153	761.05	18.6	358.2	19.8	27.5
160	761.52	19.6	394.5	23.2	26.9
167	761.09	19.0	387.0	22.5	28.4
177	760.99	17.4	343.0	18.6	28 3
188	761.26	17.4	389.0	22.8	32.5
194	761.84	17.2	413.0	25.0	35.5
202	765.17	17.0	391.0	23.0	35.6
216	764.69	15.4	299.0	14.4	30.9
225	762.70	12.6	238.0	8.8	31.5
236	761.75	14.2	299.0	14.4	34.2
240	761.23	14.2	334.0	17.6	37.1
255	769.36	15.6	379.0	21.8	41.5
265	761.91	14.8	354.5	19.5	35.7
276	763.30	11.6	274.5	12.2	37.9
294	765.86	11.8	286.5	13.2	39.6
304	767.02	12.3	303.0	14.8	40.4
314	752.34	12 8	638.3	46.4	63.7
321	752.34	13.6	711.3	52.3	67.4
324	753.86	13.6	681.0	49.6	65.2

[1] 20 scale divisions = 25 mm.

In column six of this table the increases in pressure due to the decomposition of the hydrogen peroxide are given, and on comparing these results with those given in Table I, it will be seen that the effect of the radium is to produce a much greater decomposition when lead nitrate is present than when it is not.

The Curies[1] have shown that the effect of radium radiations on oxygen is to transform it into ozone. It is to this cause that the decreases in pressure, corresponding to contractions in volume of the gas, observed in these experiments, have been attributed. Why there is this periodic change, the accumulative effect of which, as shown in Table II, is to enlarge the volume of gas, will have to be investigated more thoroughly before a suitable explanation can be given. On examining the gas which was over the liquid when the experiment was over, it was found that it contained 1.4 per cent. of ozone.

The foregoing experiments show that neither solutions of hydrogen peroxide (4.832 grams per litre), nor solutions of hydrogen peroxide in which lead nitrate is present undergo any decomposition in the dark; also that dilute solutions of hydrogen peroxide are slowly decomposed by radium, this decomposition being much more rapid when the solution contains lead nitrate and finely divided solid matter. Lastly, that ozone is produced by the action of radium on the oxygen present.

Action of Radium on Chloroform.

It is well known that the reason chloroform, $CHCl_3$, does not give a precipitate with silver nitrate, is due to the fact that it is unionized. As there seems to be no absolutely undissociated substance, there is in chloroform, probably some few chlorine ions; these are so few that when they unite with the silver ions present in the system, the amount of silver chloride is very much too small to be visible. However, as soon as these chlorine ions are removed from the system as undissociated silver chloride, more of the chloroform dissociates in

1 Loc. cit.

order to maintain the value of its solubility product, which must be exceedingly small. Thus the silver chloride accumulates very slowly and finally becomes visible. This explanation would seem to account for the appearance of silver chloride in a mixture of silver nitrate and chloroform a long time after mixing.

The following experiment was carried out to find whether chloroform could be ionized by radium to a sufficient extent, as to produce a visible amount of silver chloride when mixed with a solution of silver nitrate. About 50 cc. of chloroform which were found to produce no precipitate on mixing with a solution of silver nitrate, were placed in a wide-mouthed reagent bottle, with a capacity of about 125 cc. The brass tube containing the radium was passed through a tightly fitting rubber cork and fixed firmly into the mouth of the bottle. This solution was placed in the dark, and at the end of twenty-four hours it was shaken up with a few cc. of silver nitrate solution. After removing the water from the chloroform by allowing it to remain for a few hours over anhydrous copper sulphate, the liquid remaining possessed a milkiness which must have been due to the presence of silver chloride, thus proving that chlorine ions had been separated from the chloroform by the action of the radium.

Action of Radium on Amygdalin.

The laws of the action of light on glucosides, enzymes, toxins and antitoxins have been thoroughly investigated by Dreyer and Haussen,[1] who have shown that the effect of light on the glucosides is to cause them to break down with the formation of glucose. For the purpose of investigating the action of radium upon the glucosides, the most common one, amygdalin $C_{20}H_{27}NO_{11}$ was chosen. The amount of decomposition could readily be measured by estimating the amount of glucose formed.

[1] C. R , 1907, 145, p. 564.

A saturated solution of amygdalin in water, was subjected to the action of radium rays for four days. At the end of that time part of the solution was tested with Fehling's solution for glucose. Not the least trace of glucose was found to be present. Another part of the solution was boiled with ammonium polysulphide, and after the excess of the latter had been removed by boiling, a few drops of dilute ferric chloride were added. As there was no change in colour hydrocyanic acid was inferred to be absent. Solutions of amygdalin were acted upon by radium for different lengths of time up to ten days, with the same result as above.

Although on boiling the solution of amygdalin, which had been under the influence of radium for a time, with a few drops of Fehling's solution, the copper was not reduced, thus showing the absence of glucose, the blue colour due to the copper, almost disappeared, a whitish or pale blue gelatinous precipitate was formed, and a fairly strong odour of ammonia was given off. If more than a few drops of Fehling's solution were added to the amygdalin, the blue colour did not disappear on boiling. When Fehling's solution was added to an ordinary solution of amygdalin, it was found that the same changes took place on boiling, except that the solution of amygdalin which had not been acted upon by radium, was not able to discolour as much Fehling's solution as was a solution that had been acted upon by radium. These changes must be due to some reaction taking place between the amygdalin and the Fehling's solution, or one or more of its constituents; these reactions are more complete when the amygdalin has been under the influence of radium for a time.

Amygdalin solutions were boiled with the constituents of Fehling's solution combined in all possible ways, but it was only when they were present so as to form Fehling's solution that the above results were obtained. When a solution of amygdalin was boiled with caustic potash alone, ammonia was given off but no precipitate was formed.

Liebig and Wöhler prepared amygdalic acid or glucomandelic acid, $C_{20}H_{28}O_{13}$ from amygdalin, by boiling it with baryta water, the change taking place in this way:—

$$C_{20}H_{27}NO_{11} + 2H_2O = C_{20}H_{28}O_{13} + NH_3$$

This acid is a white crystalline substance which readily forms amorphous salts.

It is probable that the change taking place with Fehling's solution is one similar to this. The action of the potassium hydroxide is to form amygdalic acid and ammonia, and at the same time an insoluble salt of the former is formed with the copper, which is held in solution by the sodium and potassium tartrate in the Fehling's solution.

The decomposition of amygdalin by Fehling's solution does not take place unless the solution is boiled. However, if the solution of amygdalin is boiled with potassium hydroxide, cooled, and then a few drops of Fehling's solution added to it the bluish precipitate is formed.

A quantity of this precipitate was formed and washed free from amygdalin and Fehling's solution. When some of it was heated on a piece of platinum foil it charred, showing that it contained organic matter, and a greyish residue containing a carbonate and copper, but no sodium nor potassium was left behind.

From the foregoing facts it would seem that, on adding Fehling's solution to a solution of amygdalin and boiling, we have a change taking place like that observed by Liebig and Wöhler, resulting in the break down of the amygdalin. As a result of this decomposition the nitrogen of the amygdalin is changed to ammonia, and a bluish white precipitate, which is probably a copper salt of amygdalic acid, is formed. It is believed that the evolution of ammonia and the formation of the precipitate noted above, might be used for the detection of amygdalin. When the amygdalin has been under the influence of radium for a time, it is found this change is more complete.

Since solutions of glucosides are readily changed into glucose by hydrochloric acid, even in the cold, it was believed that if a solution of amygdalin were bombarded with radium radiatons, this transformation might be accelerated.

The solutions of amygdalin used for this purpose had a concentration of ten grams per litre; the hydrochloric acid consisted of one volume of acid (sp. g. 1.2) to five volumes of water. The proportion of amygdalin to acid solution was ten to one.

The amount of decomposition was determined bv titrating the glucose that was produced, with Pavy's solution, 25 cc. of which =0.0151 gram of glucose $C_6H_{12}O_6$.

To determine whether the radium exerted any influence on the hydrolysis of amygdalin, the radium was placed over a vessel containing the acid solution of amygdalin, of the concentration mentioned above, and allowed to bombard the solution for a certain time; at the end of that time the amount of decomposition was compared with that of a similar solution that had not been acted on by radium. The vessels used to contain the solutions were ordinary wide-mouthed reagent bottles with a capacity of 125 cc. The tube containing the radium was securely fixed in a wooden block, which loosely fitted over the mouth of one of the bottles. Thus, by filling the bottle to a definite mark, the distance between the radium and the surface of the liquid was always kept the same. This distance was between two and three millimetres.

The following experiments were carried out in a photographic dark room, so that there was no chance of the reaction being influenced by light. The solution which was not to be acted on by radium was protected from the rays by a screen of lead, so placed that the solution would not be affected appreciably by the secondary rays set up in the lead.

Several experiments were carried out in this way, and the amount of glucose formed was estimated after different lengths of time. In the following table the numbers given in column two

denote the amount of amygdalin solution required to decolourise 2 cc. of Pavy's solution (25 cc.=0.0151 g. $C_6H_{12}O_6$), at the specified times after the instant of mixing. The temperature at which the action took place was $18 \pm 0^\circ.5$ C.

TABLE III.

Time in hours.	No. of cc. of Amygdalin solution required to decolourise 2 cc. of Pavy's solution when acted on by		No. of grams of glucose per 1 cc. of Amygdalin solution acted on by	
	RADIUM.	NO RADIUM.	RADIUM.	NO RADIUM.
19	11.54	12.08	0.000104	0.000099
30	13.39	12.29	0.000089	0.000097
48	14.77	12.28	0.000081	0.000097
66	16.27	12.39	0.000073	0.000097

From an examination of this table it will be seen that there is a striking difference between the behaviour of solutions of amygdalin acted upon by radium and those which have not been so influenced. For the solutions that have been bombarded with the radiations from radium, the content of glucose reaches a maximum and then falls off again; but with the solutions not under the influence of radium the amount of glucose present increases with time and then remains constant. An effect similar to this has been observed by the author[1] when acid solutions of potassium iodide made up with ordinary distilled water are allowed to decompose in the sunlight or dark; and when acid solutions of potassium iodide made up with pure water (conductivity 2.16×10^{-16}), are allowed to decompose under the influence of radium. In each of these cases the content of free iodine reaches a maximum and then gradually falls off again.

It would seem that the effect of the radium is to cause the glucose, in some manner, to change into some new product. In the case of the solution of amygdalin which has not been under

[1] Loc. cit.

the influence of radium, where the content of glucose tends toward a constant asymptotic value, the simplest explanation is that the new product is not being formed, and we have an ordinary example of equilibrium between the amygdalin and its products of decomposition. If the new product is being formed two suggestions present themselves to account for the continued constancy of the glucose present: (1) that the rate of formation of the new substance is very small, but that in time the numbers in column five of the table would begin to drop also; (2) that the whole system reaches a state of equilibrium, and the amount of glucose will remain constant however long the time.

In order to ascertain whether the glucose was transformed into a simple substance or a complex one, by the action of radium, the effect of the latter on solutions of glucose in water and dilute hydrochloric acid, and on solutions of pure cane sugar in dilute hydrochloric acid was next studied.

Solutions of glucose and cane sugar of various strengths were experimented upon for different lengths of time, the change being measured by means of the polariscope. It was found that in no case was the change in the solution under the action of radium any different from that which was not influenced by radium, which seemed to show that the substance into which the glucose was changed in the amygdalin solution was not likely a simple one.

Action of Radium on Brass.

As has been mentioned before, the radium used in these experiments was enclosed in a narrow glass tube, which was held in the end of a hollow brass rod. The radium had been kept in this brass rod for about a year previous to these experiments. Some time after being placed there it was observed that the end of the brass rod, at which the radium was, began to be discoloured, and finally turned a deep grey. This discoloura-

tion was only at the surface next the air, for on scraping the surface of the rod with a knife, the inside was found to have the yellow colour of brass. While allowing the radium to act on hydrogen peroxide in the experiment previously described, where the brass rod was enclosed in an atmosphere of ozone, and air containing more oxygen than ordinary air, there was found on the part of the rod near the radium, a small quantity of this dark grey substance. Some of this was scraped off, care being taken not to remove any of the brass. On analyzing this substance it was found to contain only copper, there not being even so much as a trace of lead or zinc present. What has probably taken place is that the action of the radium on the brass in the presence of oxygen has slowly converted the copper of the alloy to copper oxide; the greater the amount of oxygen present the more rapidly the change takes place.

The results here given show that in many reactions the effect of radium is to accelerate that action already going on, and in the case of amygdalin and hydrochloric acid it may perhaps set up a new action of its own, besides accelerating the hydrolysis of the amygdalin into glucose, etc. Lastly the presence of amygdalin may be detected by boiling a solution supposed to contain it with a few drops of Fehling's solution and noting whether or not the odour of ammonia is given off.

The author's best thanks are due to Professor MacKay for the interest he has shown in these experiments.

Dalhousie University, Halifax, N. S.
March 30, 1908.

THE BEHAVIOUR OF SOLUTIONS OF HYDRIODIC ACID IN LIGHT IN THE PRESENCE OF OXYGEN.*—By H. Jermain M. Creighton, M. A., Dalhousie University, Halifax, N. S.

Read 13th April, 1908.

It is well known that solutions of hydriodic acid and acid solutions of potassium iodide readily change into free iodine and water. These reactions are accelerated by light, and also, as the author[1] has shown, by radium. While investigating "the influence of radium on the decomposition of hydriodic acid" the author[2] observed that the iodine set free by the oxygen increased with the time, reached a maximum and then gradually fell off again, under certain conditions. It was also observed that solutions of iodine placed in the sunlight slowly became colourless. It was to try to account for the disappearance of this iodine that this investigation was undertaken.

The hydriodic acid used in these experiments, was set free from solutions of potassium iodide by means of a sulphuric acid solution consisting of one volume of acid (sp. g. 1.84) to five volumes of water. The solutions of potassium iodide used had a concentration of 1 gram per litre. The proportion of acid to iodide solution was one to eight.

The amount of oxidation was determined in the usual way, by titrating the liberated iodine with $\frac{N}{1250}$ sodium thiosulphate solution.

It was found that the end point could be determined very quickly and accurately by highly illuminating the solution by means of an electric light placed behind it, and reflecting back the rays through the solution by placing a piece of white paper around the beaker on the opposite side.

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*Contributions from the Science Laboratories of Dalhousie University [Chemistry].

[1] Creighton, Proc. and Trans. N. S. Inst. Science, vol. xii, 1, 1.

[2] Loc. cit. Also Creighton and Mackenzie, Amer. Chem. Jour., 1908. 39, 4 (April).

The potassium iodide used was the chemically pure guaranteed reagent supplied by C. F. Kaulbaum.

By carrying out the titration in the above manner, the error was found to be about ± 0.08 cc. sodium thiosulphate solution.

As has already been stated, the iodine in solutions of hydriodic acid diminishes under certain conditions; in the case where the hydriodic acid is placed in the sunlight the iodine entirely disappears in time. If there was a new substance being formed, it was felt that its nature could best be ascertained from a study of the change under the action of sunlight, as this was the most easy to control and by far the most rapid.

As a starting point in this investigation, a large quantity of solution was made up in the manner previously described, and placed in a window where it would receive the most sunlight. Portions of 50 cc. of this solution were titrated with sodium thiosulphate from day to day and thus the variations in the content of free iodine were established.

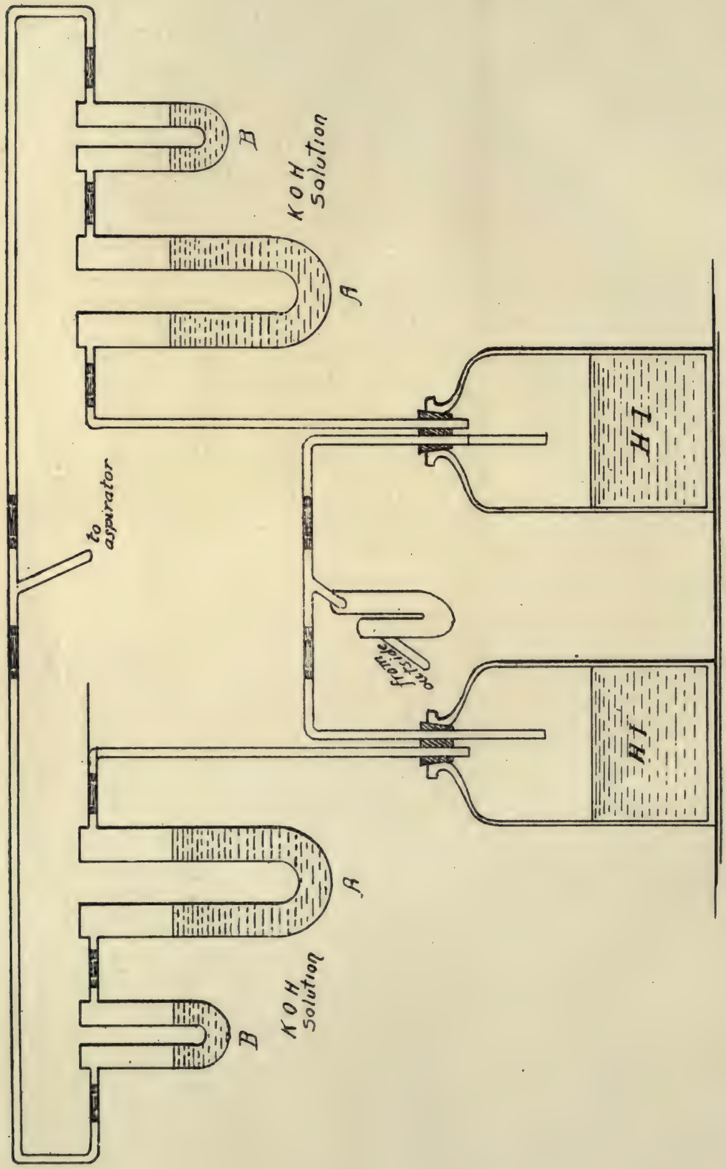
On account of the reaction being a reversible one and its point of equilibrium being changed by light, the numbers in the following table are given for the days which were of about the same degree of brightness.

TABLE I.

Time in hours.	No of cc. of $\frac{N}{1250}$ $Na_2S_2O_3$ solution required in titration when the decomposition of hydriodic acid takes place in sunlight.	Time in hours.	No. of cc. of $\frac{N}{1250}$ $Na_2S_2O_3$ solution required in titration when the decomposition of hydriodic acid takes place in sunlight.
24	46.31	552	20.42
72	58.42	720	18.55
120	64.42	840	16.62
144	58.93	888	14.26
189	52.14	960	11.80
236	49.97	1056	10.74
288	45.14	1152	6.41
408	44.12	1272	3.12
456	28.55	1368	0.46
504	23.41	1392	0.00

From this table it is again seen that the iodine content reaches a maximum very rapidly and then slowly falls off again and finally disappears. During the last two hundred hours the disappearance of the iodine is relatively rapid. In this experiment it was found that the disappearance of the iodine was due, in part, at least, to evaporation; accordingly, to see whether evaporation was responsible for the whole change, and at the same time to determine how much light influenced this change of iodine, the following experiment was carried out.

300 cc. of an acid solution of potassium iodide, such as had been used already, were put in each of two reagent bottles, one amber colour, the other clear; these were closed, and about every twelve hours the air that was over the liquid was passed through U-tubes containing a solution of potassium hydroxide (sp. g. 1.27), by means of an aspirator.



B
KOH Solution
A
to aspirator
HI
from outside
HI
A
KOH Solution
B

Fig I

The air thus removed was replaced by air from outdoors, which first passed through a U-tube containing potassium hydroxide. The air, after passing through this solution of potassium hydroxide divided, and half went to one solution and half to the other. After passing over these solutions it went, as stated, through the potassium hydroxide in the U-tubes, A and B, and then met in a common tube leading to the aspirator. By these means it was very easy to pass the same quantity of air over each solution. A diagram of the apparatus is given in Fig. 1. After the last trace of the iodine had disappeared the amount absorbed could easily be estimated. The use of the second smaller U-tubes marked B in the diagram was to make sure of the complete absorption of the iodine.

After the solution had been exposed to the action of sunlight for seven weeks, the solution in the bottle that was not coloured, became colourless. The solution in the amber coloured bottle still contained considerable quantity of iodine, and it was not for nearly another seven weeks that its colour entirely disappeared. This shows that the change of the iodine is accelerated by light, and that its loss cannot probably be totally accounted for by evaporation. On examining the U-tubes containing the caustic potash solution, it was found that the first one, A, contained iodine, while there had been none absorbed in the second smaller tube, B, showing that no escape of iodine had taken place.

The amount of iodine carried away by the air and absorbed by the solution of potassium hydroxide was next determined.

When iodine is absorbed in potassium hydroxide, there is formed five molecules of potassium iodide to one of iodate. The solution of hydroxide was acidified with sulphuric acid; and as some of the iodide might have oxidised to iodate, a little iodide was added to ensure complete decomposition of the iodate, then a few cc. of starch solution added, and the liberated iodine determined by means of sodium thiosulphate solution.

The potassium hydroxide solution from the U-tubes was diluted to 200 cc. 45 cc. of this solution were acidified and titrated with $\frac{N}{10}$ sodium thiosulphate solution, of which 1.53 cc. were required to remove the blue colour due to the iodine. From this data it may be shown that the 200 cc. of hydroxide, therefore, contain 0.0864 gram of iodine. Only one-sixth of this iodine was present as iodate in the potassium hydroxide solution, that is 0.0144 gram. The quantity of iodine as iodide was estimated by oxidising it to iodate by means of potassium permanganate solution; 1 cc. of this solution = 0.0056 gram of permanganate. 25 cc. of the solution of potassium hydroxide which had been diluted to 200 cc. was acidified slightly with sulphuric acid and then made alkaline with potassium carbonate. The permanganate solution was then added until the liquid became slightly pink. In this titration 4.40 cc. of the potassium permanganate solution, corresponding to 0.0246 gram of potassium permanganate, were required to oxidise the iodine. It will readily be seen that this amount of potassium permanganate has been used in oxidizing 0.0098 gram of iodine. Therefore, the amount of iodine in the potassium hydroxide solution as iodide was eight times this amount, or 0.0784 gram. Hence, the total amount of iodine lost by evaporation from the iodine solution and absorbed by the potassium hydroxide solution was,

0.0144	gram iodine as	iodate
0.0784	" " "	iodide
0.0928	" "	absorbed.

In this experiment 300 cc. of iodide solution (conc. 1 gram per litre) which contained 0.2293 gram of iodine, were used, From these numbers it will be seen that the loss by evaporation was 40.47 per cent., which leaves still sixty per cent. to be accounted for.

Before leaving this experiment it would be well to mention here that after all the iodine had disappeared from the solution

it still possessed a slight colour, not unlike the colour produced when Nessler's solution is added to a solution containing a minute quantity of ammonia. About a week after the last of the iodine had disappeared, this colour went also. In all solutions of hydriodic acid, where the iodine disappears, this colour was observed.

Although it seemed absolutely certain, from the fact that the second U-tube, B, in the above apparatus contained no iodine, none of it could have escaped out of the latter into the atmosphere, yet the objection arose that as the gas inside the bottles was taken out, carrying with it iodine, some of the iodine, although very unlikely, might have escaped. It was to overcome this objection that the experiment to be described was carried out.

500 cc. of acid potassium iodide solution were placed in a reagent bottle provided with a tightly fitting rubber cork, through which passed a glass tube provided with a stop-cock. This glass tube went almost to the bottom of the liquid as shown in Fig. 2. This tube was connected with a gas holder containing oxygen under pressure, the gas from which was first purified and dried, by passing through wash bottles containing sodium bicarbonate and concentrated sulphuric acid, before being allowed to enter the iodide solution.

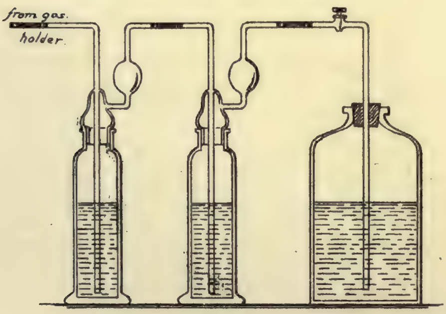


Fig 2

The stop-cock was opened, the rubber cork loosened, and the air in the bottle displaced by oxygen. The rubber stopper was then tightly fitted, the oxygen in the bottle allowed to attain the same pressure as that in the holder, and the stop-cock closed.

At the end of twenty-four hours on opening the stop-cock again, a large quantity of oxygen was found to bubble through the solution, showing that some of the oxygen there had been used up during the twenty-four hours. Every day as much oxygen as possible was forced into the bottles containing the solution, until at the end of about nine weeks, the solution had lost all its colour, with the exception of the slight peculiar colour mentioned previously. Some of the solution was drawn off and tested for iodine and iodides, but not the least trace of either was found to be present. The passage of oxygen into the solution was continued with the result, that at the end of another week, the slight colour possessed by the solution entirely disappeared. During this time it was roughly estimated that not less than twenty-five litres of oxygen, at the ordinary temperature of the laboratory and a pressure somewhat above the normal, were passed into the iodide solution.

On the foregoing grounds then, it is not unreasonable to suppose that the iodine is being transformed into some oxygen compound, and that this transformation is accelerated by light.

Creighton and Mackenzie[1] have shown in the case of solutions of hydriodic acid acted upon by radium, where the iodine content after a time begins to diminish, it is very probable it is the hydriodic acid that is transformed and not the iodine itself, thus lessening the content of free iodine by upsetting the equilibrium between the two substances. On account of the similarity between the two cases, it is possible that this is the manner in which the change takes place here.

The colourless solutions from which the iodine had disappeared were now examined. It was found that these solutions contained no iodide, but, however, a small quantity of iodate. If these solutions were allowed to stand for a few weeks after becoming colourless, before testing, there could not be obtained the slightest trace of iodate. These facts would seem

[1] Loc. cit.

to show that the process of the change is one of oxidation, through the different oxygen compounds of iodine. The amount of iodine as iodate in the solution into which oxygen was passed, just after the last trace of iodine had disappeared, was found to be 0.0000372 gram per cc. or the 500 cc. started with would contain 0.0186 gram; that is, 4.87 per cent. of the original amount of iodine.

It is evident then that the amount of iodate present in the solution will be greatest just after the solution becomes colourless; that is, never very much greater than 4.87 per cent. This will readily be seen from the consideration that no appreciable amount of iodate could exist, while there was any potassium iodide or hydriodic acid present in a solution containing sulphuric acid. Also it has been shown that the amount of iodate decreases with time, after the solution loses its colour.

It seemed a not unlikely explanation that the iodine might be changed into periodates. It would appear a perfectly natural process for the hydriodic acid to be oxidised to iodic acid, possibly through the intermediate formation of hypoiodous acid, and this quickly transformed to some of the periodic acids. Of course, there could not, and need not, be any appreciable amount of these intermediate substances present at any time. In order to test this explanation the solution was examined for periodates.

On adding a solution of silver nitrate to the acidified solution a slight milkiness appeared. 0.0062 gram of this precipitate yielded on heating 0.0031 gram of metallic silver, which amount corresponds to the quantity of silver contained in silver dimesoperiodate, $Ag_4I_2O_9 + 3H_2O$. However, it could not be this substance, as the solution failed to yield iodine on reduction.

Since from the manner in which the iodine disappeared, it was believed that the iodine must have changed to some oxygen compound, the effect of strong reducing agents were tried on the solution. Zinc dust was added to the acid solution and

allowed to act for a couple of hours; portions of the residue from the solution were heated with potassium cyanide and powdered charcoal, and with powdered magnesium; and lastly some of the residue was heated in a current of hydrogen to such a high temperature, that the sodium sulphate was reduced to sulphide. In neither of these instances was the slightest trace of iodine obtained.

As it was thought that an analysis of the solution might throw some light on the problem, the following determinations were undertaken.

80 cc. of the colourless solution that had been acted on by pure oxygen, and which, therefore, must have contained all the iodine originally in it, were exactly neutralized with potassium carbonate and evaporated to dryness. The residue after being dried at 110° for an hour weighed 8.0530 grams. This residue was used for the analysis, and the only substances that it could contain besides the iodine, were potassium, and sulphuric acid in the form of sulphate, (it was proved that there was no carbonate present).

The amount of sulphuric acid (SO_4'') was determined by precipitating with barium chloride. The following are the results obtained:

(1)	1.4914 grams residue yielded	1.9813	grams $BaSO_4$
(2)	1.4914 " " "	1.9842	" "
	mean	1.9827	

This weight of barium sulphate corresponds to 0.8168 gram of SO_4'', or to 54.76 per cent. of the residue used.

The potassium was estimated by precipitating as double potassium-platinum chloride. This precipitate after being thoroughly dried, was heated with oxalic acid and reduced to a mixture of metallic platinum and potassium chloride,

Pt + 2KCl. From this the amount of potassium was determined. It was found that:

(1) 0.4890 gram of residue yielded	0.9674 gram Pt + 2KCl.			
(2) 0.4890 " " "	0.9610	"	"	
mean	0.9642	"	"	

This corresponds to 0.2193 gram of potassium, which is 44.83 per cent. of the residue used.

These results are arranged in the following way so as to be more obvious:

	Theoretical composition of K_2SO_4	Composition of residue examined. (1) High results.	(2) Low results.
Potassium	44.87%	44.98%	44.68%
Sulphuric acid (SO_4'').	55.13%	54.81%	54.73%
	100.00%	99 79%	99.41%

When the weights of the substances corresponding to these percentages are calculated for 1.4914 grams there is obtained:

	Theoretical for K_2SO_4	Residue examined. (1) High results.	(2) Low results.
Potassium	0.6694 g.	0.6699 g.	0.6664 g.
Sulphuric acid (SO_4'')	0.8220 g.	0.8175 g.	0.8162 g.
	1.4914 g.	1.4874 g.	1.4826 g.

It will be seen that 1.4914 grams of the residue used, correspond to 14.81 cc. of solution, and should therefore contain 0.0100 gram iodine. The above analysis shows the difference between this amount of residue and the amounts of potassium and sulphuric acid (SO_4'') that it contains. The discrepancy between this difference and the amount of iodine that should be in the residue cannot be accounted for at present.

Although the results of this investigation have been negative in the main, nevertheless some information as to the behaviour of hydriodic acid in the presence of oxygen and

light has been ascertained. It has been shown that hydriodic acid in the presence of oxygen is slowly changed to something else, the colour of the solution due to the liberated iodine ultimately disappearing. This change is greatly accelerated by light. There is good reason to believe that the process of the change is one of oxidation, but all attempts to reduce this oxidation compound have failed, and the condition in which the iodine exists still remains unsolved.

In conclusion, my most hearty thanks are due to Professor Mackay for his valuable criticisms, and the kind interest he has taken in this investigation.

DALHOUSIE UNIVERSITY, Halifax, N. S.
April 2nd, 1908.

Notes on Mineral Fuels of Canada: By R. W. Ells, LL. D., F. R. S. C., Geological Survey, Ottawa.

(Read 14th. January, 1907.)

The rapidly growing importance of the Dominion of Canada, with its ever-increasing development of manufacturing industries, and its general commercial progress, calls for continued research for materials suitable for the generation of light, heat and power. To some extent the latter feature is now being supplied by the production of electricity through the utilization of the numerous waterfalls found in every province, and the power thus furnished will doubtless in a few years be sufficient not only to supply our numerous manufacturing centres, but to do away to a large extent with the use of steam on our great lines of railway. But since the varied climate of our country makes artificial heat a necessity for nearly half the year, and many industries exist for which electrical power is not readily available, a constant supply of mineral fuel will always be required. From this standpoint, therefore, a brief glance at our present known available resources in this line may not be devoid of public interest.

Not so many years ago it was the generallv accepted opinion that Canada, as a whole, was largely lacking in this element of a nation's progress. The coal fields of the Maritime Provinces were known to some extent, and had been worked on a small scale for many years, but Ontario and Quebec were regarded as entirely lacking in a natural fuel supply. As regards coal proper, this is practically true for both provinces, yet other materials exist which, as will be pointed out, will furnish a fairly good substitute for bituminous coal. Of the boundless stores of mineral fuel which have been discovered on the great

plains and in the valleys scattered through the sea of mountains in British Columbia, as well as along the Pacific coast, our knowledge even forty years ago was exceedingly limited.

The object of the present paper is to direct attention to the large supplies of this fuel which are found in all parts of the Dominion, and which are suitable for the generation of light, heat and power. The substances available for this purpose include, in addition to the several varieties of coal which range from anthracite to the newest lignite, such minerals as anthraxolite, albertite, oil-shale, petroleum, natural gas and peat.

Coal, etc.

The coals of the Atlantic provinces have been mined for nearly or quite a century. They belong to the Carboniferous period, and in point of age contrast strongly with the immense deposits found on the great western plains, along the eastern slopes of the Rocky Mountains, and further west on the Pacific coast, which belong in part to Cretaceous and in part to Tertiary rocks.

The eastern deposits have been described in numerous reports and papers, both in governmental and scientific publications. The principal areas, considered from the economic standpoint, are in Nova Scotia, where at least four well-defined coal-basins occur. Of these the most easterly, known as the Sydney area, is divided into several portions, in which a number of seams are found, aggregating probably not far from fifty feet of coal. This basin probably represents the western margin of a great Carboniferous area which extends beneath the intervening broad strait which separates Cape Breton from Newfoundland, since in the south-western part of the latter province a well-defined coal basin also occurs. The seams of the Sydney basin extend seaward, and have been worked for many years beneath the water, the extension in this direction forming a coal area of great economic importance.

Other important coal deposits in this island are in the western part, and are found in the Richmond and Inverness basins. In recent years, owing to railway construction, these areas have been rendered accessible, and large quantities are now regularly shipped both by land and water.

On the mainland of Nova Scotia, the most important coal field at present is in Pictou County, and though this field is much faulted in places, it has been worked for a century, and is noted for the immense thickness of the coal beds contained, which in one case reaches nearly or quite forty feet. In the western part of the province, in Cumberland County, the Springhill basin inland, and the Joggins basin on an arm of the Bay of Fundy, are large and important factors as regards a coal supply, and though the seams worked at these two places have as yet never been directly connected, the extension of the beds of the Joggins along the northern limit of the Carboniferous basin has been traced for many miles, and a number of collieries have been located along their outcrop. These have been producers of coal in considerable amounts for a number of years.

The Carboniferous basin of New Brunswick is extensive, comprising more than 10,000 square miles. The formation, however, is comparatively thin, and the coal-bearing rocks are regarded as of Millstone-grit age, and as beneath the Productive measures of Nova Scotia, the thick beds of that province not appearing in this direction. The workable seams in New Brunswick rarely exceed twenty inches in thickness, so that the output can never equal that of the adjacent province, but some thousands of tons are mined yearly and find a ready market. In the Upper Carboniferous formation, also, several small seams are found, but these are not sufficiently large to be mined.

In Quebec seams of coal are almost entirely absent, the only deposit of the kind occurring in Devonian slates, in a small layer two to four inches thick, on the shore of Gaspé Basin, and of no economic value. The oil-fields of this district, though

exploited for a number of years by numerous borings, have as yet failed to produce petroleum in paying quantity; but there are large areas of peat throughout the province, which, by the new process of manufacturing into blocks by drying and pressure, promise to become an important factor in the mineral resources of the province before many years. Borings for natural gas and oil in the valley of the St. Lawrence, between Montreal and Quebec, have shewn that the former occurs at several points in this district, and has been locally utilized to some extent already, though up to the present there has been no large development of these substances such as found in Ontario.

In the latter province true coals are entirely absent; but in the area south of James Bay large deposits of low-grade lignite have recently been found, which, though of poor quality, may become of value as this part of the province becomes opened up for settlement. Anthraxolite is also found in deposits of considerable extent in the old rocks of the area west of Sudbury, which are probably of Huronian age. This, at first, was regarded as possibly furnishing a new source of supply for fuel. The large percentage of impurity in the material, with its low colorific value, has hitherto prevented its utilization for commercial purposes. The large deposits of natural gas and petroleum in the Niagara and Petrolea districts have been largely utilized, the former being piped to several cities in the United States, notably to Buffalo and Detroit, as well as supplying a constantly increasing local demand. The peat deposits of this province are also being utilized for the manufacture of a very excellent fuel suitable for domestic purposes and for the generation of heat in factories and on railways.

The area north of Lake Superior is occupied bv crystalline rocks which extend westward to the shores of Lake Winnipeg, where they are again overlaid by sedimentaries of Silurian and Devonian age. The Carboniferous rocks are not found in this direction, but a broad area of Cretaceous sediments commences

a short distance west of the Red river, near Winnipeg, and extends, apparently without interruption, to the Rocky mountains. This formation contains numerous beds of coal, principally of the lignite variety.

These deposits of the west were first brought into prominence from twenty-five to forty years ago. Many of them are high grade and true coking coals, which occasionally pass into anthracite in the eastern slopes of the mountain range, while the great seams of the plains east of the Rockies still remain in the form of lignite to a large extent. Among the most important of the true coals which have been extensively worked since the building of the Canadian Pacific railway, are the large seams found in the Crows Nest pass, and along the valley of the Bow River, near Banff.

The anthracite character of these coals has evidently been developed through the agency of heat induced by pressure during the time of mountain uplift. All these western coals are therefore of much more recent date than are those of the eastern provinces. It is so far as yet known, the true Carboniferous rocks of the Rocky Mountains do not contain coal.

Between the eastern outcrop of the Cretacous rocks of the plains and the coal outcrops of the eastern slope of the Rocky Mountains, immense deposits of lignite and of lignitic coal occur. They are mined at several points, the most easterly being at Souris, near the western boundarv of Manitoba. In some places this lignite has a high fuel value, but can be distinguished from true coals, among other things, bv the fact that, unlike the bituminous variety, lignite and even the higher grade known as lignitic coal will not coke. Lignite also contains a much higher percentage of moisture than the true coals, this feature in some cases reaching as much as 15 to nearly 20 per cent. Immense beds of this lignite are found along the upper portion of the North and South Saskatchewan Rivers, and further north extend into the Peace River district. It is exten-

sively mined for local use at Edmonton on the North Saskatchewan, and at several places nearer the United States boundary.

Passing westward across the broad chain of the Rocky Mountains there follows a great belt of rocks, presenting a number of formations ranging from the Carboniferous down into the pre-Cambrian, in which no coals may be expected. But about 200 miles east of Vancouver in a direct line, or near Sicamous on the Canadian Pacific railway, coal-bearing rocks again make their appearance. These are of a still more recent date than those of the plains, being for the most part of Tertiary age. Owing, however, to greater alteration, the lignite character of the contained coals has been changed, so that the fuels from these deposits, which occur for the most part as basins resting on igneous rocks, are now in the form of true coals, and in many cases form a fuel of great value. The contained coals are sometimes of large extent, ranging in thickness from thin seams up to great beds of twenty feet, or even in some cases of more than sixty feet in thickness.

Among these important deposits may be mentioned those of the Nicola and Similkameen valleys, lying to the south of the Canadian Pacific railway; of the North Thompson, 40 miles north of Kamloops, and of the Marble Canon a few miles northwest of Ashcroft. Further north, numerous deposits of coal are found, among the most important of these being the recently discovered areas in the Bulkley valley, south of the Skeena river, and not far from the projected line of the Grand Trunk Pacific railway, where large seams of high grade bituminous coals and semi-anthracites are exposed. These promise to be of great value on the advent of the railway. Along the upper waters of the Peace river, also, several large seams of fine coal have recently been located; but at present these are not available owing to distance from transportation.

On the Pacific coast the coal-bearing rocks again change their character and belong to the Cretaceous series. Here, as at Vancouver island, are the large mines of Wellington, Nanaimo, Comox, and Ladysmith, in which area large seams occur, some of which, as in the Wellington district, have been worked extensively for nearly forty years. These not only supply the fuels for the Pacific division of British Columbia, but are shipped very largely to the cities on the American coast, as far south as San Francisco. These coals are of the bituminous variety, generally of excellent quality, and well adapted for coking. Further north, on Graham island, of the Queen Charlotte group, both the anthracite, bituminous and lignite varieties are found. The former, although exploited at intervals for nearly forty years, has never been found sufficiently firm to be mined at a profit. The alteration at this place from the lignite or bituminous coal has evidently been due to heat induced by pressure of the beds against the igneous rocks which form high mountains to the west, whereby the rocks and contained coals have been crushed, while dikes of newer rocks have also penetrated the series. Smaller deposits of anthracite have been found in the coal basin of the interior, occurring under like conditions.

In this interior basin of Graham island, however, large deposits of high grade bituminous coal occur which outcrop at several places in beds of great thickness. This part of the island gives promise when opened up, of becoming one of the most important coal fields of the Pacific slope. The containing rocks of both the bituminous and anthracite varieties are of Cretaceous age, while the eastern part of the island is occupied by Tertiary rocks, in which are found seams of lignite of good thickness.

Still further north, in the Yukon district, large deposits of lignite have been found along the Klondike and several other streams. These have been mined to a small extent locally, and will, doubtless, become important as the country is opened up.

Some of the seams contain coal of very good quality, and in the White Horse district coals of fine quality have been reported.

The northern portion of the Dominion, as along the valley of the Mackenzie river, and even on several islands off the mouth of that great stream, are known to contain coal beds, mostly of the lignite variety, which, however, have not yet been utilized.

Petroleum and Natural Gas.

In addition to the coals so briefly sketched, other sources of supply for heating and lighting are found in the presence of petroleum, natural gas, bituminous shales, anthraxolite, albertite and peat. These, with the possible exception of the last named, have a different origin from the ordinary coals. They, however, constitute a very important factor in the development of the various interests of the Dominion.

Among these, petroleum and natural gas may be regarded as the most important. In Ontario, where these occur in the greatest abundance, the petroleum has hitherto been regarded as derived from rocks of Devonian age, though that these are the original source of the gas and oil has never been conclusively established. In the oil fields of the United States, more especially in the Appalachian area, the source of the oil is as low as the Trenton limestone, while in the western or Pacific states it is found in great abundance in formations as high in the geological scale as the Cretaceous and Tertiary, so that petroleum has even a wider range than coal itself. As for that peculiar form of carbon known as anthraxolite, its range is still lower since it is found in rocks generally styled Laurentian, as well as in the Huronian and Lower Cambrian.

In the Atlantic provinces and in Gaspe, borings for oil have been carried on for more than half a century in rocks chiefly of Devonian age. Owing largely to the fact that these rocks are much broken and tilted, and often inclined at high angles, no important economic results have as yet been obtained from any

of the areas thus tested. Among the principal petroliferous rocks in the eastern provinces are deposits of bituminous shale which are found in New Brunswick, Nova Scotia and in Gaspé. Oil springs are seen at a number of points in the areas occupied by these rocks, and in part these shales are so highly charged with bituminous matter as to yield by distillation from 30 to over 100 gallons of oil per ton. Some of these form a good fuel, burning readily in the grate or furnace, the great drawback to a perfect combustible being the very large amount of residue or ash.

In the present stage of oil distillation as conducted in Scotland, Germany, France, Australia, New Zealand, and elsewhere, there would appear to be a good opportunity for successfully exploiting these bituminous shales for the manufacture of petroleum by distillation, since in the several countries just mentioned, this industry is carried on extensively and profitably on material much less rich in bituminous matter than the shales of our own country.

In natural gas, which is an industry of comparatively recent development in Canada, the advance in production has been very rapid. Large quantities have been found in western Ontario, much of which is piped to the cities of Detroit and Buffalo adjacent to Lake Erie. Natural gas has also been found in somewhat limited quantity as yet in Quebec, in the St. Lawrence Valley, and at several of the borings for oil in the eastern provinces. But little attention has, however, been paid to this industry in this part of the Dominion.

In the great north-west, however, the indications for large developments of gas are favourable. Thus at Medicine Hat, and at other points along the Canadaian Pacific railway, at Edmonton, and further north along the upper Athabaska river, it has been found, and in some places has already been applied, to the purposes of lighting and heating. At the last named

locality it was struck in immense volume in connection with the borings made some years ago by the Dominion government for petroleum, the rush of the gas being so great that the borings were suspended. At this place it has been constantly escaping for the last ten years, no attempt having been made till recently to check the enormous waste that has been going on for all this time. As the area, however, is entirely uninhabited, and at a long distance from settlement, this waste has hitherto been of less importance than if the area were near commercial centres. It is probable that in the near future, natural gas will play a very important part in the economy of the new provinces of the west and will be the great source of light and heat, as well as of power, for many of the cities of the plains.

It is also to be expected that in certain portions of the plains country, east of the Rocky Mountains, properly located borings will disclose the presence of oil-fields in that area. The oil fields of Colorado, as at Florence and Boulder, are situated on rocks practically of the same horizon, the oil there being found in the Pierre shales, which underlie the lignite-bearing Laramie sandstone. The Florence oil field has been a producer continuously for more than twenty years, several of the wells having yielded enormously. Up to the present time, in the western part of Canada but slight attempts have been made to find oil, with the exception of the borings made under government management some ten to twelve years ago, in the area along the upper North Saskatchewan and Athabaska rivers. At neither of these places, however, did the borings reach the supposed oil-bearing strata, owing largely to the great flow of gas encountered.

Peat.

Peat is found in large quantities in nearly all parts of the Dominion, and about forty years ago attempts were made to utilize certain deposits in Quebec in the manufacture of a peat fuel. As the product was simply pulped and air-dried, without

being consolidated, the results, while giving good results as a fuel both for domestic and railway consumption, were unfitted, owing to its great bulk, for the purposes required. Within the last few years, however, a series of experiments have shewn that peat, properly dried and then compressed, furnishes an excellent fuel for many purposes, and can be made and sold on the market at a good profit, the demand far exceeding the available supply, so that it is anticipated that in a few years, with still further improvements in modes of drying and pressure, this source of mineral fuel will form an important part of Canada's mineral resources.

Halifax Water Works.—H. W. Johnston, Assistant City Engineer, Halifax, N. S.

Read 12th February. 1906.

The city of Halifax is situated on a peninsula. at the head of Chebucto Bay, formed by the harbour and Bedford Basin on the east and north, and the North West Arm on the west, and joined to the mainland by a strip of land about 1½ miles wide at the Dutch Village, separating the Arm and Basin. The slopes to the water on all sides are steep, and there is a practically level plateau at the summit extending north and south about two miles and east and west one mile, with a high hill called Shaffroth's or "Hungry Hill" at the north end. The general elevation of this plateau is from 150 to 170 feet above mean low tide, and the elevation of Shaffroth's or "Hungry Hill", the highest point in the city, is 247.50 feet. There is also an elevation at Willow Park, the highest point at present supplied with water, of 225. The business district lies on the eastern slope between Jacob Street and Salter Street, surmounted by the citadel, which is 214 feet above mean low tide. The chief wharves are from Richmond to South Street, a distance of about 2¼ miles. The rest of the city, with the exception of a few streets, is residential, with few houses on the western and northwestern slopes.

The city was founded in 1749 and incorporated in 1841. Previous to 1844 the city was dependent entirely upon wells for its domestic supply, and on them and the salt water of the harbour for fire protection. It was the custom at that time on an alarm of fire being sounded for the citizens to turn out and assisted by the troops line the streets and pass buckets of water from the harbour to supplement the scanty supply from the wells, which was drawn by a hand fire pump owned by the

military authorities. In the year 1844 a company composed of local men was formed, with a capital of £15,000, under the name of the Halifax Water Company, which on the 17th of April obtained a charter from the legislature of Nova Scotia, for the purpose of supplying the inhabitants of the city with water. An amendment to the act of incorporation was passed during the same year, providing that the city council might make such ordinances as might be deemed necessary for raising such monies as might be required to furnish the city with public fountains, hydrants and fire plugs, abundantly supplied with water, by causing a fair and proportionate rate, not less than £400 in each and every year, to be made upon the whole property of the city; and that the said company should in consideration of the said annual payment of £400, erect and build in the city eighteen fountains and hydrants and twenty-five fire plugs. The first meeting of the company was held at the Exchange Coffee House on the 22nd July, 1845, when a board of directors, consisting of James B. Uniacke, Thomas Hosterman, W. A. Black, William Lawson, Jr., William B. Fairbanks, James N. Shannon, and William Stairs, were elected. Mr. Stairs refusing to act, the Hon. Michael Tobin was elected in his stead. Mr. Uniacke was elected president, and continued to act as such until 1855. Mr. Charles W. Fairbanks was employed by the directors to make surveys of the lakes adjoining the town, and on their completion Mr. John B. Jarvis, a well known engineer of New York, was engaged to report on a scheme to supply the city with water.

On the 28th August, 1845, he submitted his report to the Company recommending that the water be brought from Chain Lakes—two lakes about 2½ miles long, situated about 1¼ miles from the head of the North West Arm—by a line of pipes to a reservoir on Wind Mill Hill (now called Camp Hill), the elevation of this reservoir to be 170 feet above mean low tide. That the Chain Lakes be connected by an open channel or canal with Long Lake (formerly called Beaver Lake) about 1200

feet long, and that the surface of Long Lake be raised from its elevation of 175 feet to 200 feet above tide by a dam at its outlet at McIntosh's run. Mr. Jarvis estimated the population of the town at from 20,000 to 25,000, and that there would be 1500 water takers within five years from the introduction of the supply, and that this number would ultimately reach 2000. This would require, at 200 gals. for each tenant, 400,000 gals per day. The natural flow from the valley of the Chain Lakes was estimated to be capable of supplying the mill owners who had rights in the stream and dams already built, and to furnish the town with 300,000 gals per day for five months in the year, leaving seven months supply to be stored in the reservoirs. This supply he estimated could be obtained from the Chain Lakes storage reservoir. In his report he makes no mention of any data regarding precipitation, and the presumption is that as there were no records for Nova Scotia in existence previous to this record, the New York or Massachusetts records were taken. He recommended that a 12-inch pipe, which was estimated to be capable of discharging 800,000 gallons per day when new, but only 700,000 when incrusted, be laid from the Chain Lakes to the reservoir in the city. The estimated cost of the works, including Long Lake, the reservoir on Wind Mill Hill and the distribution, was about $120,000. The reservoir was proposed to be 1.58 acres in area and about 15 feet deep, which would hold a supply when drawn down of about 5,000,000 gallons.

Before leaving this report, there is a clause dealing with the principle of municipal ownership of water-works which should be quoted, especially as the question of municipalities owning or controlling all public utilities is to-day a very live issue. After reciting several benefits following the introduction of water-works, he says: "A good supply of pure water has a further public benefit in promoting the cleanliness, health and general comfort of the citizens. These are con-

siderations that should induce a city to supply water under their own authority. If the rates should not be sufficient the general benefits would be ample remuneration for an deficiency that might, under favorable circumstances for the introduction of water, be necessary."

A further report was submitted by Mr. Jarvis on the 10th September, 1845, on the advisability of bringing water direct from Long Lake without connecting with Chain Lakes. He reported that the cost of bringing the water by open cut to within 1500 feet of the lower end of Chain Lakes and then laying pipes, would be practically the same as the original estimate, and he could see no objection to the scheme. However, the directors adhered to the original scheme and constructed a dam at Long Lake, the canal from Long Lake to Chain Lake, and a 12-inch pipe line from Chain Lake to St. Andrew's Cross (the local name for the junction of Robie Street and Quinpool Road), but did not build the reservoir on Wind Mill Hill. Considerable trouble was had in securing the rights to Chain Lakes from the mill owners, but eventually these were secured, although on terms which have been the cause of dispute ever since.

The water was turned on to the city in 1848, the first service pipe being laid to Mr. Liswell's house and bakery on Gottingen Street on the 29th September, 1848. (The 6-inch main originally laid on this street was taken up in 1905.)

A contract with the city was made on October 3rd, 1849, agreeing to supply eighteen fountains or hydrants and twenty-five fire plugs at an annual rental of £400. In July, 1849, the directors of the company authorized a free supply of water to be given the poor from certain hydrants between the hours of six and seven morning and evening.

At this time the engineer reported that there were 2700 houses inhabited and 400 uninhabited between North Street and the gas works.

In 1849 the shareholders instructed the directors not to build the reservoir, and in 1851 the portion of the act requiring this to be done was repealed. In December, 1849, the directors issued a notice to water takers that they should during the ensuing winter keep the water constantly running in a small stream during the night to keep the pipes free from frost —an order that has ever since been only too faithfully carried out, much to the detriment of the works and the financial showing of the system.

In fact, as early as 1854, the directors, in replying to the city's complaint of poor pressure, said that the difficulty in keeping up the supply has been caused by the great waste of water, by the water takers running it off during the severe weather. In this year, finding the supply insufficient, the directors employed Mr. J. Forman to make an examination of the lakes and report on the advisability and expediency of raising Lower Chain Lake, and to what extent, and also the propriety of laying another 12-inch pipe from the head works at Chain Lakes and the advantages to be derived from it. Mr. Forman reported to the directors on the 5th August, 1854, and at a special meeting of the shareholders on the 24th February, 1855, a resolution was passed authorizing the directors to proceed with the laying of a new line of pipes, providing the opinion of a competent engineer who had not been connected with the company be first obtained. An amendment that the directors turn their attention to the immediate waste of water was defeated by a large majority. Acting under this resolution, Mr. Forman was again engaged to report on an increased supply, and in answer to a series of questions put to him, advised that the effect of a 12-inch pipe would double the supply and would cost £6,026. To give full effect to the increased supply the 9-inch, 6-inch and 3-inch distribution pipes should be changed to 12-inch, 9-inch and 6-inch. Also that a 15-inch main would give fully one-half more than the existing supply at a cost of

£8,500, and that there was more water in the lakes than a much larger pipe than one of this capacity could run, and that there would be no danger to existing distribution pipes from increased pressure. He also reported that the cost of bringing the water to the pipe-house direct from Long Lake in a conduit would cost £7,200; but he could see no advantage to be gained. By repairing and raising Long Lake dam 290 million gallons, extra storage would be gained at an outlay of £550. He did not think that a reservoir on Camp Hill would obviate the necessity of a new pipe to the lakes; but it would add to the present supply by storing water at St. Andrew's Cross when the consumption of the town was less than the flow through the mains. This would be the case at some periods and tend to preserve the effective head. In reply to the request whether he could suggest anything to remedy the present evil resulting from frost, he recommended that frequent inspections of water-cocks be made and consumers warned against allowing a more copious flow to run than was necessary.

At the annual meeting on the 2nd July, 1855, Forman's report was adopted, and the directors authorized to lay another line of 12-inch pipe if necessary arrangements could be made with the city council as to increased cost. A resolution also passed that a strict supervision be had over water takers to prevent excessive waste. The city having agreed to pay £200 per annum for an additional ten hydrants, providing some changes were made in the distribution, at a meeting 15th January, 1856, the shareholders decided to lay a 15-inch pipe, which was done in the fall of this year. The company also raised its rates to all private takers fifty per cent. The city first approached the company in this year with a view to buying the works, but the latter's reply was that they were not then in a position to sell. In 1859 a committee of the city council was appointed, after the great fire of the 9th September in that year, to report on the improvement of the fire department and on the best means of obtaining an additional supply of

water for the city. After considering several propositions this committee reported to the council recommending the purchase of the company's works by the city, and also that the Birch Cove Lakes be acquired and connected to a reservoir on Shaffroth's Hill, from whence the water be distributed by three lines of pipes, one supplying the north, one the south and the other the middle district of the city. This scheme was proposed and advocated by Mr. E. J. Longard. Acting upon this report, the council again approached the company, and at a special meeting of the latter it was resolved to sell the works to the city for £52,000, which offer the city accepted, delivery to be made on the first of May, 1860; but as the city neglected to secure the necessary legislation, the agreement fell through. In the following year, however, the sale was made to the city for £56,000. The transfer of the works was made on the 30th June, the formal transfer of the deeds, etc., being made on the 5th August, 1861.

The water company's capital when the works were taken over by the city was £44,000. There were 960 water takers at an average rate of £13 per annum, with special rates to the military, breweries, bakeries and distilleries; and £700 was being paid by the city for rental of fire and street hydrants. There was about 21 miles of pipes laid for the supply of the city. After the transfer, the works were managed on behalf of the city by a board of three paid water commissioners under authority of an act passed 15th April, 1861. The commission was composed of J. A. Bell, chairman, and Messrs. J. L. Barry and E. J. Longard, the latter taking the place of Mr. J. R. Morse, who was elected by the city council but declined to serve. These gentlemen continued to act until the control of the works was vested in a committee of the council (the board of works) on the 30th September, 1872.

Before the purchase of the works a commission on water-supply, with Mr. Henry E. Pugsley as chairman, was appoint-

ed by the city council, and they engaged Mr. James E. Laurie, C. E., of New York, to report on the works and increased sources of supply. Mr. Laurie submitted his report, which is an exceedingly interesting and valuable document, on the 10th May, 1860. The population of the town at that date was 30,000, and there were 892 water tenants on the books of the company. Allowing eight persons to a family, this would give 7,136 people using the water; but as the barracks, navy yard and city counted as single tenants and a large number were using water from free hydrants, he estimated that there were about 20,000 consumers. While the mains were capable of discharging 2,000,000 gallons per day, on account of there being only about two 12-inch distributing mains only about 1,500,000 gallons were being used by these 20,000 consumers, or at the rate of 75 gallons per capita per day. In calculating for an increased supply he based his estimate on a population of 60,000 using at the rate of 83⅓ gallons per capita per day or for a total of 5,000,000 gallons per day.

He discussed two plans for increasing the supply, and two for the proposed high service, and also improvements in the distribution system:—

1st. Long Lake.—By raising this lake three feet and replacing the 12-inch main with a 24-inch main a daily supply of 5,000,000 gallons with a storage capacity for 160 days would be obtained at an estimated cost of $70,070.00.

2nd. Birch Cove Lakes.—These lakes consist of several bodies of water connected by narrow passages, having a surface elevation of 239 feet above mean low tide, and an area of 241 acres, with several other lakes emptying into them. The natural flow was small, a 9-inch x 12-inch penstock carrying the greater part of the water in the dry season to a mill on the stream. Assuming the lakes to be capable of being raised ten feet, which was problematical, as the eastern banks were low and unsuitable for dams, and eight feet of water being drawn off,

the capacity of the reservoir would be 586,000,000 gallons or 117 days full supply for the city. But as the mills on the stream would require the whole natural flow through the summer and autumn, it would be necessary to purchase their rights, or there would be available for the city's use but forty-six days supply. The cost of bringing water from these lakes, including $40,000 for land and compensation and $30,000 for reservoir on Shaffroth's Hill, would be $353,980.

3rd. High service, Ragged Lake.—This lake lies about 2¼ miles westerly from the gate-house at Chain Lake, and contains about 100 acres of water area at an elevation of 325 feet above tide. Lying at the summit level of the country, it has a limited water-shed (less than 300 acres by a later survey) and would not be a suitable source to furnish the quantity required. The estimated cost of obtaining a supply from this source, exclusive of the distribution, was $55,030.

4th. Pumping by steam power to Shaffroth's Hill.—The most convenient station for pumps would be near St. Andrew's Cross, and the costt, including the annual working expenses capitalized at 6 per cent. would be $99,000. Another scheme was suggested—to use the stream running from the Chain Lakes to Hosterman's mill to pump into a stand pipe, and thence by gravity to a reservoir on Shaffroth's Hill. The first cost would not be very different from pumping by steam, but the operating expenses would be less. The practicability of the plan depended on the amount of water running from Chain Lakes in a dry time, the amount required to operate the pump being about 4½ million gallons per day. In summing up, Mr. Laurie recommended that Long Lake dam be raised and a 24-inch main be substituted for the 12-inch from the lakes to St. Andrew's Cross, as the whole of the city, with the exception of the district lying to the north and west of Gerrish and Creighton Streets, could be supplied by gravitation. This district would have to be supplied either by bringing water from a

higher source or by pumping to a reservoir. He also recommended extensive changes in the distribution system.

In 1863 the original 12-inch main was taken up and a 24-inch main laid in its stead. Long Lake dam was not raised until some years later, but the distribution system was remodelled and enlarged on the lines of the report. The commissioners in their annual report for this year discussed the necessity for a high service supply and warmly advocated something being done, as without artificial means being employed sufficient head could not be obtained from Long Lake to supply the higher levels of the city with water by gravity. In reviewing Laurie's report they mentioned a high hill near the foot of Chain Lakes suitable for a reservoir site, which would do away with the necessity of a stand pipe and reservoir on Shaffroth's Hill in case it was decided to adopt the method of pumping from the Chain Lakes. William Gossip, Jr., C. E., was engaged to report on the question of obtaining a high level supply from this source. On the 29th of June of this same year he submitted a lengthy report dealing with this matter and also with the general state of the works, in substance as follows:—That to pump by water-power from the Chain Lakes to a reservoir on the adjacent hill would require the following quantities of water: To work the water-wheel and keep the reservoir full (supposing 600,000 gallons per day to suffice for the high service for some years to come) 5,000,000 gallons per day, to which must be added 2,000,000 gallons for the low service, 600,000 for the high and 100,000 for leakage and waste, or a total amount of 8,600,000 gallons per day from the Long and Chain Lakes reservoirs. The lakes in their then state were estimated to be capable of sustaining a daily draught of 5,000,000 gallons without reducing the level of Long Lake to more than two feet below the waste weir in the driest part of the year, leaving a deficiency of 400,000,000 gallons. By raising Long Lake dam three feet (at a cost of $1,450) 260,-000,000 gallons additional storage could be had, leaving 140,-

000,000 gallons more required, which could only be obtained by tapping some new source. The waters of Spruce Hill Lake could be diverted into Long Lake and supply this amount by a cut about a quarter of a mile long at a cost of $16,000. The cost of the new works, using water-power for pumping, would be $61,411 and using steam-power $44,537, the annual operating charges in the former case being $800 and in the latter $3,286.50.

The commissioners, however, were imbued with the idea that the Spruce Hill Lakes, lying about three miles to the westward of Long Lake, were the best available source of supply, and in 1865 obtained the services of Mr. W. B. Smellie to make surveys and report on their capabilities. On the 5th April, 1865, he reported that he had made a survey of the lakes and found the second lake had an area of 92½ acres, and was 153 feet above Long Lake, and the third lake an area of 70 acres, and about 2½ feet higher than the second. He recommended a dam across the outlet of the second lake, raising the water 7½ feet, which would allow, say, 6 feet of water to be drawn from the second lake and 3½ feet from the third, and would yield 217 millions of gallons, or 180 days' supply of 2,000,000 gallons per day. By raising the lake one foot higher twenty-two days' further supply could be had, and by lowering the pipe three feet below the existing surface an extra quantity equal to twenty days' consumption would be obtained.

In a further report on the 8th July, 1865, the cost of building a canal to let the water of Spruce Hill Lakes down to Long Lake was estimated to be $33,500, and to conduct the water by a line of pipes to a reservoir near Chain Lakes would be $87,-000. But neither of these schemes commended itself to him, and he recommended conducting the water from the lakes to St. Andrew's Cross by a 15-inch pipe, which would be capable of delivering two and one-half million gallons every twenty-four hours.

The commissioners, after considering the various reports upon the proposed increase in supply, had no hesitation in recommending that Spruce Hill Lake be raised 10 feet, and the water conducted into the city by a line of pipes.

In 1866 the whole scheme was submitted to Mr. Thomas C. Keefer, and on September 25th of that year he submitted his report. He recommended taking the supply from Spruce Hill Lake by gravity, and estimated that these lakes would ordinarily furnish a supply of 2,000,000 gallons, and in a dry year not less than 1,000,000 gallons per diem, or sufficient for a liberal supply for 20,000 persons, or about double the number assigned to the high level district. A 15-inch pipe to within a mile and a quarter of the lake and a 20-inch pipe connected through the intervening distance to the lake would deliver 2,000,000 gallons per day at the higher levels and 3,000,000 per day at a level of 100 feet above tide. He also suggested that in future an intermediate system might be obtained by catching a portion of the Long Lake water at an elevation of 50 feet above the lake and forming a reservoir and running a line of pipes to town. In January, 1867, the city council adopted this report. Work was commenced on the 17th April, 1868, on the dam and pipe line, and the work was finished in the following year.

By an act of legislature, passed 18th April, 1872, the powers and functions hitherto exercised by the commissioners of water supply were to cease on the 30th September of the same year, and a committee of the city council called the board of works was vested with all the said powers and functions. The following quotation is taken from the first report of Mr. E. H. Keating, the first city engineer of Halifax, in 1873. Adverting to the formation of the commission in 1861, he said: "The new commission seemed to work well, and great praise is due to the gentlemen who comprised the board for the energetic manner in which they grappled with the difficulties with which they had to contend, and for the manner in which the work

of the department was planned and executed. To them is due the credit of establishing the works as we have them to-day, and if unsatisfactory it is through no fault that can be attached to the plans that were adopted, but rather through the neglect of enforcing stringent ordinances, the necessity for which I am informed was repeatedly urged upon the council by the board." Since 1872 the works have been under the control of the board of works and managed by the city engineer of the city of Halifax.

As may be gathered from the foregoing history of the works, the district supplied by the Long and Chain Lakes lies at an elevation below 150 feet above mean low tide, and that supplied by the Spruce Hill Lake system above this elevation. The former is called the low service district and the latter the high. Both are supplied by gravitation. One of the great difficulties in connection with the high service shortly after its introduction, was the constant and urgent demand of the consumers near the higher levels of the low service district, as the pressure became lower through the increased consumption for the letting down of this service to the lower levels. While this was combatted strongly by the commissioners and subsequently by the city engineer, it was frequently done, and greatly impaired the efficiency of the high service system. However, since the introduction of the 27-inch low service main the supply has been kept back nearer its proper level. At present the lowest points supplied by the high service are the Victoria General Hospital and poor house, where the ground is at an elevation of 100 feet, and on Uniacke Street, at an elevation of 120 feet.

Low Service Gathering Grounds and Storage Reservoirs.

The water shed of the low service system comprises an area of 4,455 acres, including the lakes—904 acres in the Chain Lakes and 3,551 acres in the Long Lake gathering grounds, the water area in the former being 97 acres and in the latter 459 acres. Included in the Chain Lakes water shed is Bayer's Lake

with an area of 16 acres. The run-off from this water-shed has never been measured, although some measurements of the flow from the Bayer's Lake portion have been made, and the calculation of its yield has to be made from the rainfall. In estimating the capacity of the gathering grounds there must be considered the extent and character of the drainage area, the average and minimum yearly rainfall, the distribution of the rains through the various months of the year, the average and least percentages that are carried by the streams, the storage capacity that can be secured and the evaporation from the surface of the area.

The slopes of the drainage area of Long Lake and Chain Lake are steep, and consist chiefly of rock formation with scanty soil and not very much vegetation. The rainfall is measured by the Dominion meteorological agent in the city of Halifax, and at the lakes by the city water department. The gauges at the lakes are set in such a position that they should measure accurately the precipitation. The average yearly rainfall in the city of Halifax, from 1869 to 1905, is 56 inches and the minimum 45.808 inches in 1894. In Mr. Keefer's report of 1876 the rainfall for the years 1859 to 1865 is given, and during this time a minimum of 39 inches is recorded for 1860 and an average of 51.62 inches for the seven years. It is not known by whom these records were made.

The writer is unaware of any studies to determine the evaporation having been undertaken in Nova Scotia, but the generally accepted rule here is to allow that one-half the rainfall will be lost from this cause and all that falls on the water surface of the drainage area. In his opinion this would cover the loss on the low service water-shed as there are few swamps or shallow places where the water lies, and as before mentioned, the slopes are fairly steep. In fact, taking the area of the water-shed, the amount flowing over the waste weirs, the amount estimated to be delivered in town, the loss from leakage at the dams and the amount delivered to the mill owners,

the writer is of the opinion that an average of 50 per cent. throughout the whole year is available as the run-off from the Long Lake drainage area. Since 1889 the quantity running to waste yearly over Long Lake waste weir has varied from 250,000,000 gallons to 2,173,000,000 gallons. The reservoir has always been full during those years in either March, April or May.

To increase the available flow, it is necessary to store the water in time of flood and thus equalize the distribution of the rainfall. There are three low service reservoirs,—Long Lake, with waste-weir level at 206.00 feet, having a surface area of 423 acres, an available depth of 8.20 feet and a capacity of 871,522,000 gallons; Upper Chain Lake, with waste-weir at same level and sluice at 194.70, an area of 37 acres and a capacity of 107,674,000 gallons; Lower Chain Lake, with waste-weir at same level of 206.00 feet, main pipe at level of 192.24 feet, and an area of 42 acres and a capacity of 157,374,-000 gallons; giving a total available storage in the low service reservoirs of 1,136,570,000 gallons—sufficient to supply the legitimate wants of a population of 50,000 for a period of 225 days, allowing 100 gallons per capita. But to show the enormous draught on this system, in November of 1905 all but 60,000,000 gallons of this storage had been exhausted in supplying 18,000 consumers between the 15th of June, when the reservoirs were full, and the 15th of November, the rainfall during this period amounting to 12.683 inches. The lowest level to which Long Lake has been drawn down being 8 feet below waste-weir on the 14th November, 1905. At the end of December, 1905, the level of Long Lake waste-weir was raised one foot, which will increase the available storage by 115,000,000 gallons.

High Service Gathering Grounds and Storage Reservoir.

The water-shed of Spruce Hill Lakes amounts to 1,009 acres, including a water area of 218 acres in the lake and 6

acres in Fish Pond. The geological formation is similar to that of the Long Lake water-shed, but the slopes are somewhat flatter. Mr. Keefer estimated the yield from this gathering ground in the driest year at an average of one and one-quarter million gallons per day, and that in wet years this amount would be doubled. The storage capacity of the lake is estimated to be 700,000,000 gallons, or sufficient for a population of 31,000 for 225 days, allowing 100 gallons per day per capita.

Cleaning Lakes.

In raising the Spruce Hill Lakes, the area flooded was thickly covered with trees, brushwood and moss, which apparently had never been cleaned out, and which after a short time died and greatly contaminated the water.

The effect was so bad that for a few years previous to 1876 the water became unfit for domestic use. In that year the lake was drawn down to a level of 7 feet 9 inches below the waste-weir, and the bed of the lake was cleared of fallen trees, brushwood and decomposed vegetable matter, and the stumps were grubbed out. The trees and stumps taken out were covered with a green slime. When Long Lake was raised, the shores were thoroughly cleared, but in common with all the lakes certain forms of vegetation thrive between high and and low-water level, and it has to be periodically cleaned out.

Growths.

The growth of algæ was first noticed in 1878. In that year samples of water, algæ and mud from Chain Lakes and water from Long and Spruce Hill Lakes were collected in September when the water was low and sent to Professor Lawson to analyze. His analysis of water from Long Lake yielded a dry, solid residue, as follows:—

Inorganic matter	1.71	grains to the gallon.
Organic "	2.13	" " "
Total	3.84	" " "

Another sample, taken from Chain Lakes near the pipe-house, gave:—

Inorganic matter.................... 2.48 grains to the gallon.
Organic " .... 2.68 " " "

Total.................... 5.12 " " "

The inorganic matter consisted chiefly of alumina and iron, with silica (soluble), common salt and a mere trace of lime. The water belonged to the class of soft waters such as are collected in districts where there are no rocks capable of yielding soluble substances. The sources of the impurity taken up by the water in its passage through Chain Lakes was discovered in the form of a very peculiar deposit found in Upper Chain Lake extending over the greater portion of the lake bottom, of a thickness of over five feet in level places. It varied in consistency from that of soft cheese to that of baker's bread, and in color from whitish to dark ferruginous brown, in some places nearly black. It consists to a very large extent of the remains of microscopic organisms belonging to the class of infusoria. The chemical analyses of four samples is as follows:—

No. of sample.	Color.	Insoluble in H. Cl.	Soluble in H. Cl.	Total Inorganic matter.	Organic matter.	Water.
1	Pale brown.	38.40	11.36	49.76	11.32	38.92
2	Pale whitish.	38.96	9.44	48.40	9.60	42.00
3	Between 1 and 2.	38.16	11.04	49.20	8.72	42.08
4	Dark fur. brown.	.....	.....	24.70	11.85	63.45

This deposit has no doubt originally consisted of swamp muck formed by the remains of plants, infusoria, etc., but by the long subjection to the action of water passing over it has lost much of its organic matter.

A few specimens of fresh-water sponge (Spongilla), whose decay gives a very offensive odor to water, were found in Upper Chain Lakes in 1878, and in 1883 the growth was increasing

to such an extent that men were sent to collect all the specimens that could be found, since which date no more have been observed. In 1877 a microscopic alga called *trichormus flos aqua* was found in Spruce Hill Lake, which had the effect of giving the surface of the water, especially near the shore, a brilliant green color. This is not known to be injurious, but is regarded as an indication of water being stagnant or containing organic matter. It has not reappeared, and was probably removed by clearing the lakes of vegetable matter. In 1885 new forms of algæ appeared in Chain Lakes, consisting of a galatinous substance forming in detached masses, from the size of a marble to a large apple, and adhering but slightlv to the soil and stone under water, a light breeze being sufficient to detach quantities of this substance and carry it to the screens in the pipe-house where, if allowed to collect, it would soon cut off the supply to the city. Lime scattered along the shores of the lakes seems to kill this growth, and a certain amount is deposited yearly to prevent its starting.

An analysis of the water from the various lakes was made in 1890 by Mr. Maynard Bowman, with the following results:

Source of Sample.	Solids.			Nitrogen as			Chlorine.	Phosphoric Acid.	Oxygen Absorbed.		Valuation.	Class A.	Class B.
	Blackened.	Loss on Ignition.	Dry at 100° C.	Albuminoid Ammonia.	Free Ammonia.	Nitrates.			In 15 minutes.	In 4 hours.			
Ragged Lake	..	25	42	.1470	.0471	Trace	4.7	None	2.347	6.057	137.5	III	IV
Lower Chain Lake	....	35	47	.1814	.0400	"	5.3	"	2.460	6.117	146.1	III	IV
No. 55 South Street	....	28	43	.1743	.0413	"	5.2	"	2.360	6.039	141.3	III	IV
No. 66 Bedford Row	....	28	50	.1671	.0314	"	5.8	"	2.460	6.160	144.9	III	IV
Spruce Hill Lake	..	21	36	.1671	.0400	"	6.3	"	2.620	6.314	50.3	III	IV
Wellington Barracks	....	28	46	.1814	.0400	"	6.3	"	2.614	6.243	151.7	III	IV
Quinpool Road	...	28	46	.1814	.0314	"	6.3	"	2.558	6.173	148.7	III	IV

There are two points in the above that require special consideration, viz., the high figures for albuminoid ammonia and the oxygen absorbed. An opinion based on those leads to but one result, that the water is impure.

According to Wanklyn, Chapman, and Smith, the limit for albuminoid ammonia is 0.066 parts per million for a good water, while here we have from 0.1470 to 0.1814, which is a very large excess.

This impurity is chiefly attributable to contamination with animal matter, but situated as the lakes are and considering their surroundings its origin is not apparent. Nevertheless, there is no question but that Lower Chain Lake must in the spring receive a large amount of impurity from the accumulations of the winter washed into it from the road along its banks. Ragged Lake under this head is the least of all, though its figures are much higher than they should be. As to the oxygen absorbed, 3 parts per million is considered to be the limit of a water of medium purity, while we have here more than 6.

This does not necessarily condemn the water, peaty water not being considered injurious. Still the figures are high, and the water carries a large amount of organic matter and should be filtered before use in all cases.

The following is extracted from a report of Prof. George Lawson on the foregoing analysis:—

"The result of analysis showing Ragged Lake water to contain 0.1470 parts per million of albuminoid nitrogen and the other samples from 0.1671 to 0.1814, the average of the whole being 0.1714, affords sufficient evidence of organic impurity in all the waters. The high rate of oxygen absorbed tells the same tale. In such cases it is usual to regard the albuminoid nitrogen as having its origin in sewage or animal matter, hence the great stress laid by water analysts upon the albuminoid nitrogen. Without further knowledge of them,

these three waters, with the exception perhaps of Ragged Lake, would be regarded by most water authorities as impure, unfit for use, or at least, doubtful. It may be, and I incline strongly to this view, that the acidity of our waters enables it to give results by the ordinary ammonia process which tends to exaggerate the apparent amount of albuminoid nitrogen. It is still more likely that a large proportion of the albuminoid nitrogen is due to vegetable sources. The avidity for oxygen is probably owing to peaty and other vegetable substances, as well as ferrous salts, all of which we know exist in the water and are not injurious in the way in which decaying animal matter and sewerage are. For these reasons, I see no immediate cause for alarm, but there is certainly good reason for thorough investigation as to the sources of the apparent pollution. Dr. Fox, in his book on sanitary examinations of water, etc., gives an analysis of a water closely resembling the Halifax samples (albuminoid ammonia=0.18, free ammonia=0.08, nitrates and nitrates=0.1, chlorine=4.5) and remarks, 'Such a water when the nitrates and nitrites and chlorides are insignificant cannot be condemned, but would simply be described as somewhat dirty.' It may be that our Halifax water is not essentially impure, but only somewhat dirty. Those who use it are impressed with this latter feature of the water by observing its color and sediment. As a natural water accumulated in a silicious and granitic, rocky, comparatively uninhabited district it ought to be pure and no doubt will be when measures are taken to preserve its purity. The first thing to be done is to make a thorough survey of the shores of the several lakes and their tributary streams, and of the deposits and accumulations in the lake bottoms. In this way the sources of pollution can be reached. It may then be possible to avoid or remove them and to supply Halifax with as pure water as is within reach of any city on the continent."

In October, 1905, samples were collected and analyzed by Prof. E. MacKay, Dalhousie College, with the following results:—

Source of Sample.	Ammonia.		Chloride.	Nitrogen.		Required oxygen.		Total solids.
	Free.	Albuminoid.		Nitrate.	Nitrate.			
Long Lake	.01	.222	10.5	.425	......	9.870	12.8	118.0
Tap, Young Avenue...	.014	.224	10.9	.400	......	9.80	13.4	122.8
Spruce Hill Lake	.026	.120	8.0	.300	.....	9.68	14.1	103.2
Tap, Dalhousie College.	.020	.124	7.8	.300	..	9.60	14.1	107.9

The above are given in parts per million.

In his report Prof. MacKay says: "All samples had a somewhat yellowish tint due to dissolved vegetable matter. Of the total dissolved solids more than 70 per cent. was found to be of vegetable origin. The amount of vegetable matter is relatively large, and to this is due the high values found in ammonia. The analyses showed all samples to be wholly free from indication of essentially injurious constituents or contamination."

In a paper read before this Institute, Dr. Campbell said he found the Halifax water remarkably free from bacteriæ.

Dams and Waste-Weirs.

The dam at the foot of Long Lake was built by the Halifax Water Company in 1848. It was 950 feet long and 29 feet high. The original design called for a structure 20 feet wide on top, 29 feet high above the surface, the inner slope to be 3 to 1 and the outer 1½ to 1; a puddle-wall to be built 6 feet thick, its front in line with the inner edge of the top, to be backed with 6 feet of coarse gravel, the whole surrounded with fine gravel and loam; the outer slope to be covered with

stones, the toe of the inner slope to be composed of coarse gravel and small stones; the level of the waste-weir (which was a wooden structure) to be 200.00 feet above mean low tide.

In 1877 the dam was raised and strengthened by putting rafts of brushwood and straw covered with fine material in front where leaks had developed, and raising the dam five feet, widening the top to twenty-four feet and flattening the outer slope to 2½ to 1. The water side was protected by a heavy sloping wall surmounted by a granite coping 18 inches high and forming a low wall along the front. The dam was lengthened to 1,018 feet to the west of the waste-weir. In 1892 the dam was raised two feet and strengthened by depositing 5,000 cubic yards of good material on the face. The present waste-weir at an elevation of 205.99 feet above low tide was constructed in 1878 of massive granite masonry and strengthened in 1888 by the addition of a concrete wall at the front. It is 62 feet 6 inches long and the crest is 3 wide and level, the fall from the crest to the apron being 3½ feet. The latter is constructed of granite slabs about six feet long with granite paving outside. There is a sluice-way closed with an iron gate at the eastern end, 62 inches wide and 50 inches high and at a level of 198.90.

In December, 1905, iron staunchions were secured to the top of the weir and the sill raised one foot, or to an elevation of 207.00 by placing two 6-inch timbers in position.

The highest level to which the water has risen over the weir is 25 inches on the 19th October, 1896.

In 1873 leaks were reported in the Long Lake dam by the city engineer, and in June, 1877, thermometrical observations were taken in the lake and at each of the runs of water along the foot of the dam, when it was found that the two largest runs were from leaks and the rest from springs under the embankment. Weirs were placed on these, and the actual amount of leakage was found to be 14.7 gallons per minute from the

eastern one and 6.6 gallons per minute from the western one. As the results of the improvements made in 1892 these leaks have been very materially reduced, in one case a flow of 2 inches over the measuring weir dwindling to $\frac{1}{4}$ inch and the other stopping altogether.

When Lower Chain Lake was raised in 1894, a new dam was constructed outside the existing one. It is practically two dams joined by a natural hill, the north one also having a hill projecting into and buttressing it. The north part of the dam has a concrete core-wall 4 feet wide on top and 6 feet at bottom carried down to the solid ledge-rock and continued into the banks on each side and running through the waste-weir. The embankment is formed of gravel and loam laid in thin layers and well compacted. The old 12-inch pipe used to let down water to the mill owners runs through the dam, also the 24-inch main to the pipe-house, which is at the foot of the outer slope. A leak developed where the 24-inch came through the core-wall, but it was repaired with concrete and has shown no signs since. The length of this dam is 550 feet, the top width 12 feet. The outer slopes are 2 to 1, and the inner 3 to 1, paved with heavy stones. The waste-weir is at the northern end of the dam at an elevation of 206 feet, and is of similar design to the Long Lake weir, the dimensions being 16 feet long, width of crest 3 feet, and a fall of $9\frac{1}{2}$ feet broken by a ledge $5\frac{1}{2}$ feet from the crest. The apron is paved with heavy granite slabs and concrete. A 20-inch exit pipe runs through the weir to be used as a waste pipe. The south part of the dam is constructed to the same design as the northern part, with a gate-house in the centre of it. The top and outer slopes of both this dam and Long Lake dam were covered with street sweepings hauled from town and sown with grass seed and in a year were covered with a strong, thick sod. There are two small dams between the two Chain Lakes, the south one built in 1883, with a sluice 24x36 at a level of 194.70; the north with the old waste-weir built in 1886.

The main dam at Spruce Hill Lake is an earthen structure 1,200 feet long, 12 feet wide on top the slopes, both inner and outer, being built of granite about 16 inches thick. There is no puddle or core-wall through it, but it was built by simply compacting layers of the best available material. There are two smaller dams about 300 feet and 250 feet long respectively, of the same section as the main dam. The dams were constructed in 1868 and the granite face wall in front of the dam was built in 1891-3 and the dams raised at that time. The present waste-weir was built in 1883 at an elevation of 362.79. It is constructed of granite with four openings of 9 feet 3 inches each in the clear, separated by cast-iron standards to receive stop logs to retain the surplus water. There are three such timbers in place, each 6 inches square, thus raising the level to 364.29.

Gate-Houses.

There are two gate-houses at Chain Lakes. The north one, originally built in 1857, is located at the north part of the dam at the toe of the outer slope, and consists of an iron tank built in sections, bolted together and caulked. The water is drawn from the lake to this chamber by a 24-inch pipe. It was raised in 1894 by bolting a section to the existing chamber. The 24-inch supply main is connected with this house.

The south gate-house was built in 1894, over the channel which led to the old south pipe house, which was the original one built in 1848 and destroyed when the new one was completed. The new one is built of concrete and is 16 feet deep by 12½ feet wide by 16½ feet long with walls 4 feet thick. It is drained by a 12-inch pipe. Both the 24-inch and the 27-inch mains connect in this house, but may be separated should occasion arise. There is a straining wall about 100 feet long in front of this gate-house built of loose stones, 4 feet 6 inches thick on top with slopes of 1 to 4. The new house is ample in size and avoids the difficulty always had with the north house which is too small to vent the water freely, and was always in

danger of choking up owing to the small size of the screen chambers. There is a weir near the north gate-house to measure the water let down by the 12-inch pipe to the mill owners.

The original Spruce Hill Lake gate-house was of similar design to the old ones at Chain Lake, consisting of an iron tank with three divisions, an inlet, screen and outlet chamber, and was built about 150 feet north of this dam, a 20-foot pipe running through the dam and connecting with the lake. In 1889 a permanent structure of brick, concrete and granite was built in the dam of the following dimensions: 16 feet deep by 10 feet 4 inches wide and 8 feet 5 inches long, with walls 4 feet thick.

The screens are made of No. 19 brass wire, and have sixty-four meshes to the square inch.

Employees of the water department live both at Spruce Hill Lake and at Chain Lake dams, whose duty it is to look after the dams and gate-houses. The screens, in summer when the water is low, require changing frequently as they become choked with leaves or other impurities suspended in the water. During the fall of 1905, when the water was at its lowest, two men were on duty day and night continually changing the screens, otherwise the supply could not have been kept up to the city through them.

Canal.

As has already been stated, the water was conducted from Long Lake to Chain Lakes by a canal, which was originally constructed in 1848 by an open cut, and was intended to be low enough to draw the water of Long Lake down seven feet below the waste-weir level, but during construction, owing to difficulties met with by the contractor, the grade line was raised 1 foot 3 inches, thus, only allowing 5 feet 9 inches of Long Lake water to be drawn off. The conduit was 2 feet by $2\frac{1}{2}$ feet, and was entirely too small to pass the water in sufficient volume to give full effect to the storage of Long Lake. The present

conduit, rebuilt in 1886, is 1,300 feet long, $3\frac{1}{2}$ feet wide and $4\frac{1}{2}$ feet high, built of 4-inch by 4-inch hemlock deal, with four manholes throughout its length. Its upper end is at an elevation of 196.20, with a fall to Chain Lake of six inches.

Ice.

The experience with the formation of anchor ice has been similar to that of other places. With a sheet of open water at a temperature of 32 degrees F., and the temperature of the air varying from 5 degrees to 20 degrees above zero, and a high wind blowing, the ice forms in small detached needles or crystals. Thin portions of it accumulate in spongy masses and float along at or below the surface, their specific gravity differing but little from that of water. They adhere readily to all solid bodies with which they come in contact, and grow rapidly when once they have secured a centre of crystallization. It will not form in bright sunshine—on the contrary, it rises to the surface in spongy masses, and when the surface freezes over it lets go its grip. The lee side of a reservoir gets most of its anchor ice, and whenever we have been troubled with it the wind has always been from a north-westerly direction. Between 1883 and 1893 no trouble was had from ice, and it is thought that this was due to the fact that a screen of stout pickets driven into the bottom, capped on top with a boom rising and falling with the level of the water, was placed in front of the gate houses. In 1892 this was removed, and on the 11th December of that year ice closed the sluice gate at the south gate-house cutting off the supply to the 24-inch main, and continued until four o'clock in the morning, when the wind subsided, and the ice stopped running. In 1898 the filter wall already referred to was built in front of the south gate-house, but ice formed inside the wall, and there was danger that the gate-house would freeze up solid, so the screens were removed until the danger had passed. This is the last time there has been any trouble from it.

Riparian Rights.

When the Halifax Water Company decided to bring the water from Chain Lakes there were several mills situated on the stream flowing from the lakes and enjoying the privilege of the water from them. Some difficulty having arisen in securing the rights to the water, it was seriously contemplated by the company to bring the water direct from Long Lake. However, an agreement was eventually made in 1849 with the owner of the privileges, that for a consideration of £500 the water company could build dams and take the water from Chain Lakes, provided that they would not interfere with the natural flow through the lakes as heretofore enjoyed by the mill owners. The first difference arose in 1863, when the commissioners of water-supply received a letter from the attorneys of the mill owners, stating that the mills had closed down for want of water, and that in previous years the water company had let down a supply in dry weather. The commissioners on this occasion gave orders to their superintendent to let down enough water to fill Chocolate Lake, on the understanding that this was not to be taken as a precedent or to act as any acknowledgment of the rights of the mill owners to the supply, and on April 13th, 1863, they presented a lengthy report dealing with these claims. From that time to this there has been constant friction with the mill owners as to the amount of water which should be let down to them under the agreement. This has culminated in an action being brought by them for a declaration of their rights and an injunction restraining the city from interfering with their supply. As this is now before the courts the question may not be discussed fully, and is mentioned only to serve as an example of the necessity for looking to the demand for a largely increased supply always following the introduction of water to a town in a short time, and of the advisability of either securing all the rights to a watershed, or at least, having a definite agreement as to the actual quantity to

be allowed the owners, and the method by which said quantity should be measured.

Mains.

The water was originally brought from the Chain Lakes to the city by a 12-inch main to St. Andrew's Cross, laid in 1848, and was assumed by Mr. Jarvis to be capable of delivering at this point 800,000 gallons daily. It was of cast iron, and was ordered in Scotland through Messrs. Kidston & Son, of Glasgow, and cost £7 5s. per ton delivered, the freight being 15/ per ton. 2,550 feet of these pipes were to be $\frac{5}{8}$ inch thick, to be tested to withstand a pressure of 160 pounds to the square inch, and 13,650 feet to be $\frac{1}{2}$ inch thick tested to 145 pounds. All pipes were to be 9 feet long. 550 of these pipes were ordered with spigots cast on them to fit a $\frac{3}{4}$-inch iron service pipe, so that the water would not have to be turned off in making connections. The pipes were uncoated and were laid with lead joints.

In January, 1856, the water company ordered from Kidston & Sons 284 lengths of 15-inch pipe, 9 feet long, $\frac{3}{4}$ inch thick, to be laid in the valley of the North West Arm, and 1,341 lengths $\frac{5}{8}$ inch thick; the pipes to be tested to 165 and 135 pounds respectively. These pipes were laid during that year alongside the 12-inch. The estimated delivery of this pipe was over 1,000,000 gallons per day at St. Andrew's Cross. Messrs. Kidston wrote to the directors recommending the use of a coating (Smith's patent varnish) which was then just coming into use, and the directors wrote saying that if this coating had the approval of authorities in Great Britain to put it on the pipes; but subsequently, fearing it would reduce the capacity of the pipes, passed the following resolution, a copy of which they sent their agents:—

Resolved,—That the directors having ordered a 15-inch pipe, which was larger than was contemplated for the very purpose of preventing the pipes filling up, do not consider that the

glazing mentioned will be necessary; but if the glazing is considered an advantage that all the small pipes ordered be glazed.

Fortunately, before this letter was received, the order had been placed and the pipes came out coated. These pipes were laid with wood joints. The cost was £5 14s. 10d. per ton, exclusive of freight.

In 1862 the commissioners of water-supply took up the original 12-inch main and substituted therefor a 24-inch main. These pipes were ordered from Glasgow. The quantity required for the North West Arm valley to be 1 inch thick, tested to 200 pounds; and the remainder to be $\frac{3}{4}$ inches, tested to 150 pounds. All pipes to be 9 feet long and coated with Smith's patent coating. They were laid with wooden joints and cost £4 4s. 3d. per ton, exclusive of freight or duty, or £6 18s., exclusive of truckage. The total cost of laying this main was $54,994.39, or an average cost of $4.00 per lineal foot. The estimated capacity was $5\frac{1}{4}$ million gallons when new. There is a 12-inch exit pipe at the Dutch Village Road. On the introduction of the "high service" in 1868, the 15-inch main laid in 1856 was used as a part of the supply main and was extended to within $1\frac{1}{4}$ miles of Spruce Hill Lakes, this latter distance being laid with 20-inch pipe. These are $\frac{5}{8}$ inch thick and the 15-inch are $\frac{3}{4}$ inch. They are 9 feet long and coated with Smith's patent varnish and are laid with wooden joints. That portion of the old 15-inch lying in the valley of the Arm was uncovered and lead joints substituted for the wood. On the 14th January, 1869, the commission had a report from their superintendent, complaining that the 15-inch pipes laid the previous year were giving considerable trouble from the fact of the unequal casting, a number of pipes breaking under a pressure of 68 pounds. On examination these pipes were found to be only $\frac{3}{8}$ inch thick on one side and full $\frac{7}{8}$ inch on the other, and during the winter the pressure was regulated so as not to exceed 45 pounds at Chain Lakes pipe house. The pipes split along the thin side. The

estimated capacity of this main when discharging at an elevation of 250 feet was 2,485,000 gallons. There are exits in this main at the end of the 20-inch, at Beaver Dam Brook, at head of Chain Lakes, and at the Dutch Village Road.

In 1893 a new low service main, 27 inches in diameter, was laid from the Chain Lakes. This main follows the route of and is laid alongside the other two supply mains, to the brow of the hill on the western side of the Dutch Village Road, thence striking across the valley in a straight line to Bayer's Road near North Kline Street, thence along Bayer's Road and in prolongation thereof to Kempt Road, and then to Young Street at the corner of Gottingen Street, connecting there with a 24-inch main running to Cogswell Street, where the latter joins the 12-inch and 15-inch running from the 24-inch at St. Andrew's Cross. The specification for this pipe calls for three thicknesses—$\frac{3}{4}$, $\frac{7}{8}$, $1\frac{1}{32}$,—the first to test to 250 pounds, and the latter to 300 pounds per square inch, and while this test is being applied the pipes to be struck a series of sharp blows at various points throughout their length with a 3-pound hammer attached to a handle 16 inches long. The pipes are 12 feet long with turned and bored joints, and coated inside and out with coal-pitch varnish. The contract price delivered in Halifax, free of all charges, was $32.05 per 2,000 pounds for plain pipe and $56.10 for special castings. The contract for excavating the trench was let for $1.85 per cubic yard for rock and 28 cents for earth excavation; measurement limited to a trench 4 feet wide. The cost of the 27-inch main laid was $5.71 per lineal foot, inclusive of all charges. The cost of the 24-inch laid in Gottingen Street was $5.52, inclusive of all charges. This main slopes from the lake and from Gottingen Street to the Dutch Village Road, where a 12-inch exit pipe is placed.

Coating.

The coating on the high service main and on the 24-inch was ordered as "Smith's patent varnish." This is probably the

coating process of Dr. Angus Smith, which was first introduced in the United States in 1858. The weight of experience seems to show that in uncoated pipes the first ten or twelve years of their life results in more or less rapid corrosion. After they have become thoroughly tuberculated very slight changes take place. If this is removed by scraping or cleaning it begins to form again, and the life of the uncoated pipe becomes much reduced.

The interior of coated pipes become tuberculated in the same way, due to a large extent to defects in the coating, but very much less quickly, and when removed by scraping the iron is uninjured. The writer was present recently when a piece of pipe was cut out of the 15-inch main, and when the deposit was rubbed off the coating was as sound and good as when first put on. The outside of the pipe was also in good condition. The pipe had been cleaned a year previous, and the tubercules had not begun to form, but there was a slight deposit over the face of the pipe. The following points should be observed in coating cast-iron water pipes:—

That the ovens in which the pipes are heated before being dipped in the coal tar bath shall be so arranged that all portions of the pipes shall be heated to an even temperature.

The pipes should be heated to a temperature of 300° F. before being dipped.

The varnish to be heated to a temperature of not more than 300° F., and kept at this while the castings are in the bath.

The pipes should not be submerged for less than five minutes, and when taken from the bath should be evenly coated.

Joints.

There are three kinds of joints in use in the water system, —lead, wood, and turned and bored. These latter joints have been in use since 1890, but they do not seem to find favor with engineers in America and are very little used in Canada or the United States; although in the Metropolitan Water Works of

Mass., for the crossing of the Charles River, one of the three kinds of joints used was described as follows: Three turned grooves were made in the bell instead of the single one so as to hold the lead more securely, and the spigot was smoothly turned with a straight taper to a standard pattern so as to be interchangeable. After inserting one of these tapering spigots in the bell of the pipe and running the joint with lead the spigot could be withdrawn, and when again inserted would make a tight joint. This is practically one pattern of a turned and bored joint. In the pattern used in Halifax a lip or rim is cast on the spigot end of the pipe, varying in length from $2\frac{1}{4}$ inches in a 27-inch, to $1\frac{3}{4}$ inches long on a 6-inch pipe, tapering about 1-24 of an inch in its length. A finished lip or rim is cast in the hub, the pipes are then centered in a lathe and the rim on the spigot end is turned and the rim on the hub end is bored by the same movement of the lathe. Care is taken that the pattern is made to give a full size casting so that when planed down the ends fit accurately. The total depth of the hub varies in the different sizes from 4 to 5 inches.

In laying, the pipe is lowered into the trench with the joint smeared with oxide paint, and placed in position on the blocking, entering the faucet of the last laid pipe. The next pipe is then lowered and held in its slings while the men in the trench swing it backwards and forwards and thus ram the last laid pipe tightly home in its place. A block of hard-wood between the pipes are lowered with a derrick. Should there be any slight diameter are held in slings by four men on the bank; larger pipes are lowered with a derrick. Should there be any slight weepage the joint soon rusts tight. In the fifteen years' experience with this form of joint there have only been two discovered leaks through them, one in the 27-inch main near Young Street, and one in the 6-inch main in Young Avenue. In the latter case the pipe was laid in the sewer trench. As the back filling of the latter settled, the blocking of the pipe was disturbed and the pipe settled and drew one joint. In the

case of the 27-inch, a leak developed during the winter following the laying of the pipe, and on digging down to the main a joint was discovered to have drawn out about $\frac{3}{4}$ of an inch. This was caulked with cold lead and gave no trouble until the following winter, when it again showed signs of leaking, and on investigation the joint was found to have drawn another $\frac{1}{2}$ inch. The blocking of the pipes on each side had apparently not settled out of place, being laid on the top of the ledge rock. It was thought that this drawing apart of the joint might have been due to the contraction of the pipes. Assuming the difference of temperature to have been 30 degrees, which is a fair estimate between the temperature of the pipes when laid and when the leak developed, the contraction to open the joint $\frac{3}{4}$ inch would have to take place through 324 feet of pipe. If this took place on each side of the defective joint there would be a strain on the joint of over 16 tons, the pipes weighing a ton and a quarter to the 12-foot length, if the leakage was from this cause, it should close up again in the summer when the temperature of the pipe rose. Unfortunately, the $\frac{1}{2}$ inch which is said the pipes separated in the second winter was not measured accurately, but was estimated by the foreman and may have been overstated; but assuming it to be correct, the writer cannot advance any theory for the increase in the opening from this cause, as there would not be any more difference in the temperature than the amount given above. It is possible that the joint may not have been driven home, and as at this point there was only about four pounds pressure when testing, the oxide paint used may have prevented the leak showing when the pipe was tested on being laid, and a settlement may have occurred in one or two lengths of pipe distant from the leak dragging the pipe apart at the weakest point.

It will be seen from the description of the method of laying, that the process of lowering and blocking is exactly the same as for plain pipe, except the ramming home, which takes but very little more time than the extra care required in centering the pipe for a lead joint and then the joint is complete; whereas,

with the plain pipe the process of joining has not yet been begun and necessitates considerable labor and material being employed to finish the work. To get the best results with lead or wood joints also requires a higher class of labor. The pipes can be sprung around curves, but in this case should be caulked with lead.

Previous to the introduction of the turned and bored pipes, wooden joints were used extensively for pipes of 6 inches and over. They have the merit of cheapness as compared with the lead joint and are durable, but possess the defect of being liable to be blown out with a sudden increase of pressure, and most of our trouble with discovered leaks has been from this cause. The faucets of the 24-inch and 15-inch for this kind of joint were made tapering $\frac{1}{8}$ inch inwards. The joint is made as follows:—After the pipe is inserted in the socket it is raised up by means of a tool called a raising iron and soft pine wedges or staves, thoroughly seasoned and cut to the radius of the pipe, are inserted on the lower side for about $\frac{1}{3}$ of the circumference of the pipe. The pipe is then lowered, and raising irons are driven in the top and on each side of the joint, at intervals of about 3 to 5 inches. The wedges are then driven in with a sledge-hammer beginning from those already laid and working up both sides, the raising irons being withdrawn as the work proceeds. When all the wedges are in, keys are driven where necessary between them to tighten the joint.

The wood joints in the 15-inch main, where under the water of the Chain Lakes, were strengthened by adding an angle strap of wrought-iron bolted closely to the pipe in front of the wedges. The difference in cost of turned and bored, and plain pipes, has varied from 55 cents to $1.00 per ton, the former being the difference in the tenders for the 27-inch and 24-inch pipes laid in 1893. The net saving over lead joints in laying the 27-inch man amounted to $3,147. Taking the cost of turned and bored pipes at 75 cents per ton more than plain pipes, the following table gives the detailed cost of laying mains with turned and bored, lead, and wood joints.

Cost of Laying and Jointing, 9 feet lengths of C. I. Pipe with Wood, Lead, and Turned and Bored Joints.

		Wood.					Lead.							Turned and Bored.			
Size in inches.	Weight of 9' length.	No. of pipes six men will lay and test in 10 hours, costing $10.20.	Cost of labor per length.	No. of staves @ $1\frac{3}{4}$. No. of wedges @ $\frac{1}{4}$.	Cost of staves and wedges.	Cost of one length laid, jointed and tested.	No. that 6 men will lay and test in 10 hours, cost $10.20.	Cost of labor per length.	Llbs. lead @ $3\frac{1}{2}$c.	Cost of lead.	Lbs. gasket @ $6\frac{1}{4}$c.	Cost of gasket.	Cost of one length laid, jointed and tested.	No. that 6 men will lay and test in 10 hours, cost $10.20.	Cost of labor for each length.	Extra cost of pipe per length @ 75c. per ton.	Cost of one length laid, jointed and tested.
24	2077	10	$1 02	22	$0 44	$1 46	10	$1 02	50	$1 75	$\frac{1}{2}$	$0 04	$2 81	15	$0 68	$0 75	$1 43
20	1263	12	85	19	38	1 23	12	85	40	1 40	$\frac{1}{2}$	04	2 29	18	56	47	1 03
15	1128	15	68	16	32	1 10	15	68	30	1 05	$\frac{1}{3}$	02	1 75	23	44	42	86
12	680	20	51	13	26	77	20	51	24	84	$\frac{1}{3}$	02	1 37	32	32	25	57
9	500	25	41	12	24	65	25	41		60	$\frac{1}{4}$	02	1 03	40	25	19	44
6	280	30	34	9	18	52	30	34	17	42	$\frac{1}{8}$	01	77	50	20	11	31
4	156	....	...	....	.....	....	40	26	12	28	1-10	01	55	60	17	05	22
3	130	....	...	...	.....	....	50	21	8	21	1-10	01	43	......	.....	....	...

Incrustation of Pipes, and Cleaning.

In 1875 the old 3-inch water pipes laid by the Halifax Water Company having become almost choked up with rust and sediment, they were cleaned out during the succeeding year by a scraper attached to iron rods and propelled by hand. The scraper had four arms or knives, attached to a center and sprung outwards by a thick rubber disc. This method was not practically applicable to pipes of a larger diameter than 12 inches. The cost of cleaning was 14 2-10 cents per lineal foot. In 1880 about a mile of 12-inch pipe was cleaned by a self-acting mechanical scraper, imported from Scotland, and known as the Kennedy scraper. 1887 Mr. Keating, the city engineer, at that time, constructed new scraping machines which differed from the others in having additional springs for the cutters and pistons. These scrapers consist of an iron rod to which are attached two pistons and two sets of cutting tools, one in front of the other. The cutters are each made up of four strips of steel 2½ inches broad, sloping backwards from the rod, and at their outward termination sharpened like the barbs of an arrow, thus they can yield when necessary and the cutting diameter can be altered by moving the steel strips. The pistons are of iron, lead and leather to which are added rubber springs. All the main supply pipes were cleaned in that year at an average cost of 2 8-10 cents per lineal foot. The immediate results were that the average pressure on twenty-five hydrants on the wharves increased from 34.2 pounds in February, 1881, to 52.4 pounds in February, 1882. These were on the low service. On the high service there was a pressure of 19 pounds on hydrants where in the previous year there had been no water at all. The pipes have been cleaned periodically since that date and usually twice a year.

In cleaning the mains the water is turned off at the gate-house and the exit opened and pipes emptied. A section of pipe, jointed with collars and bolted together, is removed and

the scraper inserted by hand into the main. The piece taken out is then replaced and secured. The water is turned on, and by its power forces the scraper along. As it passes the exits they are turned off by men stationed there, and the scraper continues its course to the end of the main where a length of pipe has been removed. A sufficient quantity of water escapes through the valves ahead of the scraper to wash the incrustation removed and keep it from sticking. The water is allowed to run for some time until the sediment disappears, when it is shut off and the length of pipe inserted again and the water turned on to the distribution pipes. The average cost of cleaning the 24-inch low service main for the past twenty years has been 15.07 for each cleaning of 13,400 feet, and of cleaning the high service main $18.80 for each cleaning of 36,340 feet. Between 1882 and 1904, both inclusive, there has been cleaned 223 miles of mains at a total cost $732.07, or at an average rate of $3.28 per mile.

Distribution Mains.

The pipes in the distribution system are of cast iron, all those laid since 1855 being coated, and those 6-inch and over laid before 1890 having mostly wooden joints. They range in size from 3 inches to 24 inches in dameter, the mains to the hydrants being, with few exceptions, taken from a 6-inch pipe or larger. Some of the old 3-inch mains lately removed and replaced with larger pipes, when cut, were found to be so choked that there was barely room to insert a lead pencil through the opening. These were old, uncoated pipes and the metal had deteriorated badly. The mains are generally laid on the north and east sides of the streets, with valves set in line with the street lines. Iron pipes with sleeves were first used for stopcock boxes about 1862, before that wood had been used. The valves used for letting the high service into the low for purposes of fire protection are kept clear from ice and snow during the winter.

In 1905 there were 69.68 miles of mains and distribution pipes, and 804 valves.

Hydrants.

There were 424 hydrants in use at the end of 1904. A large number of these are of an old style set in a brick-well or chamber below the sidewalk inside the curb. The chamber is covered with a cast-iron plate, provided with a hatch, by which access is gained to the bottom of the hydrant where it joins the branch from the mains. This arrangement, while admitting of the easy removal of the hydrant, is objectionable on account of the difficulty and expense in keeping the valves free from ice, and the large iron plate becoming smooth and dangerous to pedestrians. These hydrants are gradually being replaced by a hydrant of a special pattern. The main valves and guide-rod, which also forms the waste valve, are similar to the Matthews' hydrant. A brass and leather attachment to the valve rod forms the waste valve. There is a waste hole bored in the center of the flange in the stand pipe against which this valve works. The hole was formerly at the bottom of the hydrant, but owing to the difficulty of reaching it, it has in the later patterns been placed in the side. The main screw of the valve rod is protected from the action of frost and water by a partition and stuffing box. The frost jacket is securely bolted to the iron seat, and when once set need never be removed. It forms an air chamber which prevents the frost from reaching the valve. A third nozzle is added to take the suction hose of the fire engines. The hydrants are examined and opened twice a day by the employees of the water department all through the winter.

Service Pipes.

When the city took over the works in 1861, only about one quarter of the number of families on the line of pipes were supplied with water directly by service pipes to their houses, the remainder obtaining their supply from the free domestic hydrants paid for by the city. These service pipes were in all cases ¾ inch cast iron pipes connected to the distribution mains

by spigots cast on the latter. When on the assumption of control of the works by the city, a general assessment was levied to provide the funds necessary to maintain them, all citizens on the line of pipes applied for service pipes to their properties. There had been considerable doubt in the minds of the directors of the water company as to the material to be used for service pipes, and in 1846 they asked Mr. Jarvis for a report as to the merits of tin-lined lead pipes for this purpose. He replied that three-quarters of the service pipes used in New York at that time were common lead pipes, and adds that there was considerable discussion then going on as to the injurious effects of lead pipe on water. He had no doubt they injured a pure water, but that the length is so short that no material influence is produced. However, the water company, as before stated, laid all service pipes of cast-iron. The commissioners of water-supply decided to use lead pipes, and during their first year in office they laid over $6\frac{1}{2}$ miles of lead service pipes to supply water to 1,058 takers. A large number of these were renewals as the old $\frac{3}{4}$ inch iron pipes were found to be badly choked and corroded. Since that time all services have been lead pipes. While Halifax water is a very soft water, and as such, from general observation elsewhere, should be injuriously affected by lead pipes, such has not been the case, the experience being that after a short time a film or layer of sedimentary deposit forms over the surface of the pipe which prevents the water coming in direct contact with it. No cases of lead poisoning from using the water have been reported since the introduction of lead pipes for services in 1861. Under the regulations of the water department, each building is entitled to one $\frac{1}{2}$ inch service pipe laid at the department's expense from the main to the street line. In the event of a larger pipe being required the difference in cost is paid for by the person desiring the same. In the winter of 1882-3 a very large number of underground leaks were discovered and were found to result from the service pipes being severed at the connection with the

main. The gas company had the same trouble during this winter, and the city engineer at the time suggested that the only cause of this could be from shock of earthquake felt on the peninsula on the 31st December, 1882. Subsequent to the explosion of the Acadia Powder Company's works at Waverley (about 12 miles from Halifax) on the 1st January, 1905, the gas company had the same trouble with a number of their service pipes, especially on Coburg Road and in that vicinity, but the water pipes escaped injury.

At one time in the history of the works eels were a constant annoyance in choking service pipes, but latterly it is quite rare to have any bother from this cause. An exception to this was in 1896, when owing to the danger of ice blocking the screens at the pipe house they were removed, and the following spring there were several complaints of service pipes being choked by eels.

The total number of service pipes laid up to the first of January, 1904, was 6,939.

Consumption and Waste.

In January, 1906, three Venturi meters were received from the makers, to measure the quantity of water flowing into the city. One of them the 15-inch, was installed, and it was hoped that results would have been obtained before the reading of this paper, but owing to delay in sending the registering apparatus no records have as yet been obtained.*

* The Venturi meters having been set and put in operation during the period between the reading of this paper and its publication, the exact consumption has been obtained, and this note is added giving the revision of the figures in accordance with the information thus gained. For the 24 hours ending at 1 p. m. on the 6th December, 1906, the following quantity of water passed through the meters:—

Through the 14″ meter	2,291,500	gallons.
" 24″ "	4,492,500	"
" 26″ "	4,586,000	"

Making a total of 11,370,000 imperial gallons flowing into the city. This would give a consumption of 140 gallons per day per consumer on the high and 477 gallons per consumer per day on the low service, or an average of 321 gallons per day per consumer, or taking the whole population of the city, an average consumption of 277 gallons per capita per day. The figures given in the body of the paper were conservatively estimated, and while startling enough, were considerably below the actual results, which are unequalled by any other city of which the writer has any knowledge.

The Venturi meter is different in principle, design and operation from the water meters generally used for measuring water, it consists of two truncated cones of cast-iron, joined at the smallest diameter by a short throat lined with brass having a diameter varying in different meters from one-quarter to one-half of the diameter of the large ends of the cones, the three parts making what is known as the meter tube. At the up-stream end and at the throat small holes are drilled into the tube, from which pipes are carried to the register. The operation of the meter is due to the fact that when water is flowing through the tube the pressure at the throat is less than at the up-stream end, and that the difference in pressure is dependent upon the quantity of water flowing through the tube. The differing pressures at the up-stream end and throat of the meter tube are transmitted through small pipes to the register, which can be located at any convenient point within 300 to 400 feet of the tube. In the register the differences of pressure affect a column of mercury which carries a float. The position of the float is thus made dependent upon the quantity of water passing through the meter; and by suitable mechanism the quantity is recorded by a counter, and the rate of flow at intervals of ten minutes is recorded upon a chart, so that the fluctuations in the flow throughout each day can be observed. Although the pressure at the throat of the meter is often several pounds less than at the inlet or up-stream end, the lost pressure is almost all regained by the time the water reaches the outlet end of the tube, so that the net loss of pressure caused by the meter is seldom more than one pound under ordinary conditions of use. The meters in Halifax are set on a by-pass so as not to interfere with the operation of the scraper in cleaning the mains.

As there has been no direct means of measuring the water used it has had to be estimated by finding out the loss of pressure by friction in the pipes by gauges placed on hydrants at different points, and to estimate the co-efficient to use

in the Chezy formula. In a report on the water system of St. John, N. B., it was found, by experiment, that the co-efficient to use there was 65. For new pipe this should be about 120, so that the discharge from their 24-inch main laid in 1873 would be a little more than one-half that of a new pipe. The 24-inch and 15-inch in Halifax have been cleaned regularly twice a year for some time, although the usual fall cleaning was omitted last year on account of the lowness of the water in the lakes; but from an inspection of the condition of the pipes where cut this year, the above co-efficient of 65 is considered much too low for the mains of the Halifax water-works system, and 80 would be nearer the mark, although this is considered a minimum. However, assuming 80 to be applicable, the amount of water flowing into the city on the 8th of January, 1906, was 3,288,600 gallons through the 24-inch main, 4,294,000 gallons through the 27-inch main, and 1,600,000 gallons through the 15-inch main, or a total of 7,582,600 gallons for the low service and 1,600,000 for the high, or 9,182,600 for the whole city. The day was mild and there had been but little frost for some days previously. There are 19,000 consumers on the low service and 16,400 on the high. This would mean an average consumption for all the water takers of 260 gallons per capita per day, or 399 gallons per capita on the low service and 98 gallons per capita on the high.

Our population as given by the last four census returns is as follows:—

1871	29,582	1881	36,100
1891	38,437	1901	40,332

The figures for per capita consumption were given for the actual number of consumers. The better and usual practice is to give the per capita consumption for the total population as there may be some industries using large quantities of water, the employees of which may not be using water for domestic purposes. The figures given above would show a consumption

for the entire population (assuming it to be 41,000) of 224 gallons per capita per day. From exhaustive investigations undertaken by the Metropolitan Water Board of Massachusetts, the conclusion arrived at was that a liberal supply for domestic purposes is 25 gallons per day, for manufacturing, mechanical and trade use 23.5 gallons, and for public use 7 gallons, making a total of 55.5 gallons per capita per day. Taking these figures as being applicable to Halifax, the consumption should be 2,275,000 gallons per day, which means that 6,907,680 gallons per day are being wasted. The average daily consumption through 144 meters on dwelling houses of various values in the city amounts to 105 gallons for each service pipe. Allowing five persons to a family, this would give 21 gallons per capita per day, which agrees practically with the amount stated above as being a fair and liberal allowance for domestic use. Another proof that the figures of the daily consumption are under estimated, is the fact that during the past year on the low service supply over 1,000 million gallons of storage was used up during 155 days which would equal 6,500,-000 gallons per day.

If 60 gallons per capita per day be assumed as a fair allowance, it follows that at least 170 gallons per capita per day brought into the city is wasted either through leaks in the mains or water pipes and fittings in private premises. There is no doubt considerable leakage from the mains, particularly on the low service where so many of them are laid with wood joints; and a number of them are laid through or near old drains and sewers, so that the leaks do not show at the surface but the water runs off through drains. In Milton, a small town in Massachusetts, where all the services are metered and where the total quantity of water supplied is measured, and there are 35 miles of pipe laid, the leakage from the mains amounts to about 3,600 gallons per day per mile of pipe. In Fall River it amounts to 10,000 gallons per day per mile of pipe, although in their case they have only 96 per cent. of their services

metered, and the consumption for the other 4 per cent. is estimated; and in seven cities having over 86 per cent. of the services metered the amount of water unaccounted for varies from 3,500 to 23,000 gallons per mile per day (these amounts are in United States gallons). Waste from pipes and fittings on the premises of water takers is due to defective plumbing or to negligent or wilful waste in allowing the water to run from the taps. In a house with modern plumbing the chief cause of waste is from a leaky ball-cock in the tank supplying fixtures. In one instance a meter was put on a pipe supplying a closet where the valve in the flushing cistern was worn and did not fit its seat properly. The waste was but a trickling stream, but the consumption was 1,073 gallons a day, while after the valve was repaired it was reduced to 43 gallons. In other houses closets supplied with hopper-cocks are the chief cause of waste. There are at present about 450 of these in use in the city. In 1891 a test was made on nine of these closets, and applying the results then obtained there would be a waste from this source alone of three-quarters of a million gallons per day. During the cold weather an enormous amount of water in the aggregate is allowed to run to prevent pipes freezing. As up to the present there has been no means of accurately measuring the water supplied to the city, this amount cannot be stated in gallons; but the pressure at night at the various permanent gauges throughout the city drops from five to ten pounds below that of the day time. The modern method of controlling waste is to supply each taker through a meter, so that each consumer pays only for the water used. There were on May 1st, 1905, 6,939 service pipes, of which 5 per cent. were metered. In October, 1905, when owing to the small rainfall there was danger of the supply becoming exhausted a house to house inspection by the police was ordered, and wherever any leaky fixtures were found the water was turned off and only turned on again when repairs had been made and on payment of a fine. The immediate result of this was a gain of eleven pounds

pressure all over the city, notwithstanding there was a loss of $3\frac{1}{4}$ pounds owing to the lowness of the lakes. This in conjunction with the fact of the pressure lowering at night would seem to prove conclusively that the waste from the mains bears a very small proportion to that from negligent and wilful waste.

The following table of the data of the consumption of water of eleven cities about the size of Halifax gathered from late reports is here inserted to enable a comparison to be made, and also to show the effect meters have on the consumption of water. It will be noticed that the average consumption of those cities having over 50 per cent. of their services metered is 41 United States gallons, and those under 50 per cent. 91 gallons, or 50 and 197 imperial gallons per capita respectively:

Town.	Population supplied.	Number of services.	Percentage of services metered.	Miles of pipe.	Consumption. Daily.	Consumption. Night rate.
Brocton	37,800	....	90.	....	36	....
Woonsocket	34,474	.....	86.7	....	28	.....
Newton	35,400	..	86.	......	54	......
Malden	36,900	6,700	63.4	82.	47	25
Haverhill	37,200	....	10.	....	95	.....
Waltham	24,550	....	6.	....	99	......
Quincey	26,800	4,850	3.1	83.7	89	57
Salem	36 250	......	3.	......	79	.....
Everett	28,000	4,670	1.	42.	81	55
Chelsea	35,000	6,251	2.	38.7	94	65
Halifax	35,400	6,939	5.	69.6	260	.....

Financial.

The rates are levied from four sources,—meter, fire protection, domestic and special.

The meter rates vary from 15 cents to 7 cents per 1,000 gallons by a sliding scale, depending on the quantity of water used per day. A meter rental is charged on all meters except

those on domestic supply. The consumer pays only for the actual quantity used, and there is no minimum rate for this class of consumer. The fire protection rates are levied on the assessed value of all lands and premises and are paid by all classes of consumers.

The domestic rates are levied on the assessed value of properties and also on the number of fixtures, the minimum rate for fire and domestic purposes being $4.00 where no meter is on the premises.

Water is supplied to the military and naval properties and the Intercolonial railway under special agreements, in the former cases at so much per fixture and in the latter by actual measurement of water consumed, with a lump sum added for fire protection. No mains are extended in the distribution system unless a bond is executed guaranteeing the interest at 5 per cent. on the actual outlay required. This business-like method of making extensions has been the means of assuring the revenue keeping pace with the expenditure. The following statement shows the amount of the funded debt and annual cost of maintenance in five year periods since the city took over the works.

1860	Funded Debt,	£ 71,900	—The cost of the works, £56,000 paid for this year	
1865	"	$ 640,000	—Nova Scotian currency.	
1870	"	669,653.33	—Dominion currency.	
1875	"	740,973.33		
1880	"	740 973.33	- Maintenance	$55,496.46
1885	"	740,973.33	"	58,605.76
1890	"	633,906.48	"	66 534.96
1895	"	990,266 67	"	65,894.91
1900	"	1,056,600.00	"	69,252.38
1905	"	1,056 600.00	"	83,511.77*

* Includes cost of renewing old 3-inch mains with 4-inch mains.

Fungi of Nova Scotia: First Supplementary List.—By A. H. MacKay, LL. D., F. R. S. C., Halifax.

Read 11th December 1905; revised to November 1907.

This list is the first supplement to the "provisional list" presented to the Institute on the 8th December, 1902—three years ago—and published in the *Transactions*, vol. xi, page 122. My colleagues contributing to this list are (1), Mr. R. R. Gates, M. A., of Middleton, Annapolis county [in 1907, doing post-graduate work at Chicago University]; (2), Mr. Clarence L. Moore, M. A., of Pictou Academy [at present, 1907, principal of county academy and public schools, Sydney] and formerly a post-graduate student in Johns Hopkins University; (3), Miss Minnie C. Hewitt, science teacher in the Lunenburg Academy; and (4), Mr. W. P. Fraser, B. A., science master in the Pictou Academy (last collection in 1906). The list is not large, and some of the determinations may be inexact, but it is hoped that the annual publication of new species found will stimulate these and our other students of the fungi to more energetic and systematic exploration and study of the species indigenous to the province.

It is also expected that the corps of workers now taking an interest in our fungi will, before long, enable us to correct any wrong determinations, if there are any, in this and in the provisional list of 1902. The nomenclature will then be revised so as to keep in touch with the most modern classification, and a new and more complete list be published. In the meantime, the general order and nomenclature of M. C. Cooke, which were followed by our earliest fungologists and by the provisional list, will generally govern the order and nomenclature of this supplementary list as far as convenient. The author-

ities are noted in the usual manner by their condensed initials; RRG, CLM, MCH, WPF, and AHMK.

Species Not Reported in the "Provisional List."

Amanita frostiana Pk. Point Pleasant Park, Halifax, AHMK. Middleton, RRG. Poisonous. It approaches in appearance *A. muscaria,* but is much smaller. Lunenburg, MCH. New Glasgow, WPF.

A. rubescens Pers. Point Pleasant Park, Halifax, AHMK. Common in woods, Middleton. Said to be edible; but even the expert should use caution if experimenting with it. It is distinguished from the other Amanitas by the reddish color which suffuses the stem and other parts when bruised, RRG. New Glasgow and West River, Pictou county, WPF.

A. flaviconia Atkinson. New Glasgow, WPF.

Lepiota cristata A. & S. Lunenburg, MCH.

L. granulosa Batsch. Lunenburg, MCH.

L. illinita Fr. Lunenburg, MCH.

Armillaria robusta A. & S. Middleton, edible, RRG. Lunenburg, MCH.

A. viscipedes Pk. Lunenburg, MCH.

A. ponderosa Pk. (?). Lunenburg, MCH.

Tricholoma schumacheri Fr. Middleton, RRG.

T. imbricatum Fr. Lunenburg, MCH.

T. virgatum Fr., var. *acutum.* Middleton, RRG.

T. brevipes Bull. Lunenburg, MCH.

T. albobrunneum Pers. Middleton, RRG.

Clitocybe ectypoides Pk. Middleton, RRG.

C. ochropurpurea Berk. Middleton, edible, RRG.

C. fumosa Pers. Lunenburg, MCH.

Collybia butyracea Bull. Middleton, edible, RRG.

C. acervatus Fr. Lunenburg, MCH.

Pleurotus petaloides Bull. Lunenburg, MCH.

Mycena latifolia Pk. Middleton, edible, RRG.

M. leaiana Berk. Middleton, RRG.

Omphalia campanella Batsch. New Glasgow, WPF.

Pluteus cervinus Shæff. New Glasgow, WPF.

Clitopilus micropus Pk. Middleton, rare, RRG.

Pholiota caperata Pers. Middleton, edible, RRG.

P. squarosoides Pk. Lunenburg, MCH.

Hebeloma glutinosum Lind. Lunenburg, MCH.

H. crustuliniforme Bull. Lunenburg, MCH.

Galera tenera Schæff. Lunenburg, MCH.

Stropharia æruginosa Curt. A group of this species was found in October of 1904 near the door steps of the house of Mr. Watson Bishop, in Dartmouth. It was remarkable on account of its more or less azure-blue green color, due to the colored slime mainly, for the ground color was more or less yellowish. Its spores were purple tinged. This fall only very small caps developed in the same spot, presumably on account of the unusually dry autumn season, AHMK.

S. stercoraria Fr. Dartmouth Park, Halifax Co., AHMK.

Hypholoma perplexum Pk. Halifax and Dartmouth, AHMK. Middleton; "From *H. sublateritium* it is distinguished by its usually smaller size, more slender hollow stem, the yellow-greenish and purplish tints of the gills, and the absence of a bitter flavor;" C. H. Peck, Memoir, N. Y. State. Museum, No. 4, vol. 3, Nov. 1900, RRG. Lunenburg, MCH.

Cortinarius cinnamomeus Fr., var. *semi-sanguineus* Fr. Middleton, edible, RRG.

Paxillus involutus (Batsch) Fr. Middleton, edible, RRG.

P. atro-tomentosus (Batsch) Fr. New Glasgow, WPF.

Hygrophorus pudorinus Fr. Middleton, RRG.

H. fuligineus Frost. Middleton, edible although exceedingly glutinous. Common in woods, especially under pines after the autumn frosts, occurring with the following Middleton species, RRG.

H. limacinus Fr. Lunenburg, MCH.

H. flavodiscus Frost. Middleton, edible, RRG. Lunenburg, MCH.

H. distans Berk. Lunenburg, MCH.

H. puniceus Fr. Halifax, AHMK. Lunenburg, MCH.

H. coccineus Schæff. Lunenburg, MCH.

Lactarius scrobiculatus Scop. Middleton, RRG.

L. aurantiacus Fr. Middleton, RRG.

L. deceptivus Pk. Middleton, edible, RRG.

L. theiogalus (Bull) Fr. Middleton, edible, RRG.

L. volemus Fr. New Glasgow, WPF.

L. hysginus Fr. Middleton, edible, RRG.

L. chelidonium Pk. New Glasgow, WPF.

L. pallidus Fr. Dartmouth, AHMK.

Russula foetens Fr. Middleton. Has a heavy empyreumatic odor, RRG. Pictou county, WPF.

R. brevipes Pk. Lunenburg, MCH.

R. flavida Pk. Lunenburg, MCH.

R. variata Bann. Purple capped Russula, Dartmouth, AHMK.

Craterellus cantharellus (Schw.) Fr. Dartmouth, AHMK.

Marasmius cohærens (Fr.) Bres. Pt. Pl. Park, Halifax, AHMK.

Boletinus porosus Pk. On new made lawn, New Glasgow, WPF.

Boletus piperatus Bull. Common in open fields, Middleton, RRG. New Glasgow, WPF.

B. scaber Fr., var. *fuligineus*. Middleton, edible, RRG. var. *fuscus*, Lunenburg, MCH.

B. ornatipes Pk. Middleton, edible, RRG.

B. subglabripes Pk. Middleton, RRG.

B. versipellis Fr. Common, New Glasgow, WPF.

B. salmonicolor Frost. Dartmouth, spores, 8-9 microns x 3. AHMK.

B. rubinellus Pk. Under conifers, New Glasgow, WPF.

B. unicolor Frost· Lakes, Dartmouth, AHMK.

B. peckii Frost, var. *lævipes*. Pt. Pl. Park, Halifax, AHMK.

B. eximius Pk. Point Pleasant Park, Halifax, AHMK.

B. conicus Rav. Spores 12 x 4 microns, Dartmouth, AHMK.

B. affinis Pk. Waverley, Halifax county, AHMK.

B. purpureus Fr. Dartmouth, AHMK.

B. bovinus L. Lunenburg, MCH. Dartmouth, AHMK.

Polyporus (fomes) ribis Fr. On the bases of old red currant bushes, Dartmouth, AHMK.

P. hispidoides Pk. On dead trunks of *Picea*. New Glasgow, WPF.

P. schweinitsii Fr. Dartmouth, AMHK. Lunenburg, MCH. (*Phæolus sistotremoides* Murrill.)

Hydnum cyathiforme Schæff. Common near Pictou town, in thickets of spruce and fir, CLM.

H. scabrosum Fr. Lunenburg, MCH.

H. graveolens subzonatum Pk. Middleton, RRG.

Phæodon fennicus (Karst.) Hennings. On the ground under conifers. Merigomish, WPF.

Tremellodon gelatinosum Pers. A few specimens were found on decaying firs or spruce lying on mossy ground in the woods above Hartley's Waterfall, Pirate's Cove near Mulgrave, Strait of Canso, Nova Scotia, on the 29th Sept., 1904. Dr. G. U. Hay and AHMK.

The following descriptive note was made on the largest specimen about 36 hours after collection, when it must have shrunken considerable. Pileus white, opal-like, spatulate, spines white, 500 by 600 microns long, 250 to 300 microns broad at the base, from which they taper to the points which are distinctly recurved towards the stipe. Length of specimen 15mm, breadth of the fan-shaped frond 7 mm, and of the stipe 4 mm. Spores 6 to 7 microns in diameter. The whole was shrinking

very rapidly while drying and becoming smoky brown and opaque.

Clavaria pistillaris Linn. Middleton, edible, RRG.

C. fusiformis Sow. Middleton, common, edible, RRG.

C. vermicularis Scop. Lunenburg, MCH.

C. ligula Schœff. Growing under conifers. French River and New Glasgow, WPF.

C. mucida Pers. Growing on decaying log. New Glasgow, WPF.

Exidia glandulosa Fr. Middleton, RRG.

Dacromyces stillatus Nees. On railroad ties, Middleton, RRG. New Glasgow, WPF.

Phallus dæmonum Rumph. Lunenburg, MCH.

Bovista pila B. & C. Common, Pictou, WPF.

Lycoperdon wrightii B. & C. Lunenburg, MCH.

Septoria acerina Peck. On leaves of *Acer pensylvanicum,* New Glasgow, WPF.

S. œnotheræ West. On leaves of *Oenothera biennis,* New Glasgow, WPF.

Colletotrichum lindemuthianum (Sacc. and Magnus) Briosi and Cavara. On cultivated beans. New Glasgow, WPF.

Phragmidium subcorticium (Schrank) Wint. Common on *Rosa,* New Glasgow, WPF. On *Rosa blanda,* Pictou, CLM.

Triphragmium clavellosum Berk. On leaves of *Aralia nudicaulis*, New Glasgow and West River, WPF. Pictou, CLM.

Gymnoconia interstitialis (Schlecht) Lagerh. *Cæoma nitens* (Schw.). Sori form orange colored confluent patches on the under side of the leaves of *Rubus strigosus.* Pictou, CLM.

Coleosporium solidaginis (Schw.) Thum. On *Aster patens.* Pictou, CLM.

Melampsora medusæ Thum. On leaves of *Populus grandidentata.* The areas surrounding the sori become almost coal black in color early in autumn. Pictou, CLM.

Peridermium balsameum Peck. The aecidia are white, arranged in two irregular rows on the under side of the leaves. The whole leaf takes on a bleached appearance. I have only found this species occurring at considerable altitudes. Pictou, CLM.

Peridermium decolorans. Peck. On *Picea rubra.* Pictou, CLM.

Peridermium elatinum (A. & S.) K. & S. On *Abies balsamea*, causing the formation of "witches' brooms." Pictou, CLM.

Puccinia suaveolens (Pers.) Rostr. Pictou, appearing throughout spring and summer on the leaves and stems of the Canada thistle. Affected plants appears very rarely to mature seed if at all, CLM. On leaves of *Carduus lanceolatus*. New Glasgow, WPF.

P. taraxaci Plow. On *Taraxacum officinale.* Pictou, CLM.

P. coronata Corda. Common on leaves of *Avena sativa.* Pictou and New Glasgow, CLM, WPF.

P. rubigo-vera (DC.) Wint. On leaves of *Agropyron vulgare.* New Glasgow, WPF.

P. orbicula Peck and Clinton. On *Nabalus.* New Glasgow, WPF.

P. menthæ Pers. On *Mentha.* Piedmont Valley, WPF. Pictou, CLM.

P. circææ Pers. On *Circæa.* French River and New Glasgow, WPF. Saltsprings, Pictou, CLM.

P. cicutæ Larch. On leaves of *Cicuta maculata.* Piedmont Valley, WPF. Pictou, CLM.

P. asteris Duby. Common on *Aster macrophyllum.* Westville, WPF.

P. violæ (Schum.) DC. Common on *Viola.* Pictou, CLM and WPF.

P. claytoniata (Schw.) Syd. On *Claytonia virginica.* Loch Broom, WPF.

Puccinia acuminata Peck. The sori form cushion-like, dark purple spots on the under sides of the leaves of *Cornus canadensis.* On the upper side a corresponding depression marks the position of the sorus. Pictou, CLM.

Puccinia sessilis Perse (?). On *Maianthemum canadense.* Pictou, CLM.

Ustilago levis (Kellerman and Swingle) Magnus. On *Avena sativa,* WPF.

U. nuda (Jensen) Kellerman and Swingle. Common on *Hordeum vulgare,* WPF.

Sphacelotheca hydropiperis (Schum.) DeBary. On *Polygonum sagittatum.* Pictou and Piedmont Valley; WPF.

Entyloma lineatum (Cke.) Davis. On leaves of *Zizania aquatica.* New Glasgow, WPF.

Uromyces trifolii. (Hedw). Lev. On *Trifolium pratense* and *T. repens.* Pictou, CLM.

Uromyces caladii (Schw.) Farlow. On *Arisœma trifolia.* New Glasgow, WPF. Saltsprings, Pictou, CLM.

Chrysomyxa pirolœ (DC.) Rost. Middleton, forming a bright yellow coating on the under surface of the leaf of *Pyrola elliptica,* RRG.

Cystopus candidus (Pers.) Lev. Pictou, common on *Capsella Bursapastoris,* CLM.

Uredo agrimoniœ (DC.) Schrœt. Common on leaves of *Agrimonia eupatoria,* WPF. Saltsprings, Pictou, CLM.

Cercospora callœ Peck and Clinton. On leaves of *Calla palustris.* New Glasgow, WPF.

C. leptosperma Peck and Clinton. On the leaves of *Aralia nudicaulis.* New Glasgow, WPF.

Cladosporium herbarum (Pers.) Link. On decaying fungi. New Glasgow, WPF.

Sepedonium chrysospermum (Bull.) Fr. Common on Boleti, (Conidial stage of *Hypomyces chrysospermus*), WPF.

Empusa muscœ Cohn. Pictou, common everywhere on the house fly, more particularly during the autumn months, CLM.

Sporodina grandis Link. Pictou and New Glasgow on decaying *Boleti*, WPF.

Onygena equina (Wild) Pers. Growing on the hoofs of horses. New Glasgow, WPF.

Sphærotheca castagnei Lev. Collected at Pictou 28th Aug., 1905, on *Bidens frondosa*; and 21st Sept., 1905, on *Taraxacum officinale*, CLM.

Phyllactinia suffulta (Reb.) Sacc. Pictou, 2nd Oct., 1905, on leaves of *Alnus incana*, CLM.

Uncinula salicis DC. Collected at Pictou, 15th Sept., 1905, on species of *Salix*, probably *discolor*, CLM.

U. circinata C & P. Pictou, 10th Oc., 1905, on leaves of *Acer rubrum*, CLM

Podosphæra oxyacantha. Pictou, on *Spiræa salicifolia*. Noted on *S. tomentosa*, CLM.

Microsphæra alni D. C. Pictou, very common on Lilac, the mycelium appearing in July and spores maturing in August and until late in the fall. Also common on *Alnus incana*, 2nd Oct., 1905; and on *Viburnum cassinoides*, CLM. On leaves of *Syringa vulgaris*, New Glasgow and Pictou, WPF.

M. erineophila Peck. Collected near Saltsprings, Pictou county, 10th August, 1905, on leaves of *Fagus ferruginea* affected with leaf mites, CLM.

M. vaccinii (Schw.) Pictou, 3rd Oct., 1905, on *Gaylussacia resinosa*; 1st Oct., 1905, on *Epigæa repens*, CLM.

Erysiphe communis Wall. Collected at Pictou, 29th Aug., 1905, on *Oenothera biennis, Ranunculus acris, and R. repens*, CLM.

E. cichoracearum DC. Collected at Pictou, 23rd Sept., 1905, on various species of *Solidago*, CLM.

E. galeopsides DC. Pictou, 10th Aug., 1905, near Saltsprings on *Chelone glabra*. Common on this host in shaded situations and on the lower shaded leaves of plants growing closely together, CLM.

E. aggregata Peck. Collected at Pictou, 25th Aug., 1905, Very common on the fertile aments of *Alnus incana*—as many as two-thirds of them being affected over considerable districts. Spores were forming at date of collection but were not mature. Spores mature about May of the spring following. *Alnus viridis* does not seem to be so susceptible to its attacks, CLM.

Helvella crispa Fr. Middleton, RRG.

Geopyxis carbonaria (A. & S.) Sacc. Middleton, RRG.

Peziza vesiculosa Bull. Middleton, RRG.

Chlorosplenium æruginosum Tul. Pictou county. Ascocarps on rotting trunks of *Fagus ferruginea,* 3rd Sept., 1905. Also on decaying *Alnus incana.* The fructification of this species is said to be rather uncommon, CLM. Middleton, commonly occurring on rotten wood giving it a green color and making it phosphorescent, RRG.

Exoascus robinsonianus Giesenhagen. Deforming the bracts in the pistillate aments of *Alnus incana.* Very common, WPF.

Elaphomyces cervinus (Pers.) Schroter. Pictou, under beech trees; parasitized by *Cordyceps ophioglossoides,* CLM. Subterranean at the base of pine stump, Pictou WPF.

Claviceps purpurea Fr. Pictou, on barley, 2 Oct., 1905, CLM. On *Agroyprum repens,* New Glasgow, WPF.

Cordyceps ophioglossoides Ehr. Collected at Pictou, 23rd Sept., 1905, growing in leaf mould under beech trees in a subterranean fungus probably a species of *Elaphomyces,* CLM. Parasitic on *E. cervinus,* Pictou, WPF.

Hypomyces viridis (Albertini and Schweinitz). Middleton, rare. The same as *H. luteo-virens.* Identified by Prof. W. G. Farlow, Cambridge, Mass., U. S. A. The host in this case was not determined with certainty, but it appeared to be *Hygrophorus pudorinus* Fr. The gill surface only was attacked, becoming a dark green.

Xylaria polymorpha Grev. Pictou, collected in August and September, and at Saltsprings. Appears here to grow exclusively on rotting *Fagus ferruginea* on which it occasionally becomes very abundant, CLM. Middleton, RRG.

Daldinia concentrica (Bolton) Ces. and DeNot. On dead *Ulmus americanus*, New Glasgow, WPF.

Phyllachora graminis (Pers.) Fckl. On *Agropyrum repens* New Glasgow, WPF.

Dothidea pteridis Fr. On *Pteris aquilina*, near Yarmouth, by Miss E. Chesley Allen, AHMK.

Dimerosporium collinsii (Schw.) Collected at Pictou 10th Sept., 1905, on leaves of *Amelanchier canadensis*. The affected leaves frequently persist on the branches through the winter and spores mature in May of the following spring.

Podospora amphicornis Ell. Collected 10th Aug., 1905, on rabbits' dung at Saltsprings, Pictou county, CLM .

The Myxomycetes.

Mr. C. L. Moore, M. A., published in *The Bulletin of the Pictou Academy Scientific Association*, Vol. I., No. 1, June, 1906, a list and general sketch of *thirty-three* species of *Myxomycetes*, under the title, "The Myxomycetes of Pictou County," Nova Scotia. A monograph of the Myxomycetes of Pictou County by Mr. Moore, may appear soon in the Transactions of the Institute; so that there will be no advantage in the enlargement of the present list to contain a reprint of the list of 1906.

Species Previously Reported but Found in New Localities, with Notes.

Amanita vaginata Bull. *Amanitopsis vaginata* (Bull) Roz. Middleton, generally mouse colored, but often variable; a yellowish brown form occurring in this vicinity; also the deadly poisonous *A. phalloides*, common in woods, RRG.

Lunenburg, MCH, and also *verna, cæsarea,* and *muscaria*. New Glasgow, *vaginata, verna,* and *muscaria,* WPF.

Armillaria mellea Vahl. Common on decaying stumps, especially of *coniferæ,* in the neighbourhood of Halifax, Pictou, Middleton, AHMK and RRG. Lunenburg, MCH.

Tricholma equestre, sejunctum and *columbetta.* Lunenburg. MCH.

Clitocybe laecata Scop. Common near Halifax. (Var. *striatula*), Pictou and Middleton. Variable, not poisonous, RRG and AHMK.

Clitocybe nebularis, candicans and *multiceps.* Lunenburg, MCH.

C. clavipes Pers. Shelburne, CSB. Middleton, RRG.

C. infundibuliformis Schæff. Pictou, September, CLM.

Pleurotus serotinus Schrad. Edible. Middleton, RRG. Truro, JMS. Pictou, AHMK. Lunenburg, MCH.

P. lignatilis Pers. Lunenburg, MCH.

Collybia platyphylla and *dryophila.* Lunenburg, MCH. *C. radicata,* New Glasgow, WPF.

Mycena galericulata Scop. Lunenburg, MCH.

Omphalia umbellifera L. Lunenburg, MCH.

Pluteus cervinus Schdæff. Edible, Middleton, RRG, Halifax, JS.

Naucoria pediades Fr. Lunenburg, MCH.

Psalliota campestris, Stropharia semi-globata, and *Hypholoma sublateritium.* Lunenburg, MCH.

Psylocybe fœnisecii P. Willow Park, Halifax, JS. Glace Bay, Cape Breton, N.S., R. A. H. MacKeen, M. D. This latter species was identified by C. H. Peck, State botanist, of New York, to whom I referred it after receiving it with a communication containing the following information from Dr. MacKeen:—

"Early this week I was called to attend three children ranging in age from 3.5 to 4.5 years. The history I obtained was practically the same in each case.

"The parents noticed a staggering gait, inability to talk, and a tendency to laugh in a hysterical way. When I saw the patients some time had elapsed from the appearance of the first symptoms. There was a marked dilation of the pupils, flushed face, inability to stand, restlessness, occasionally an idiotic laugh. The appearance was one of intoxication. The children lived some distance apart but had been playing in the backyard when taken sick. There was practically nothing alarming as pulse, temperature and respiration were normal. The whole impression seems to have been made on the nervous system.

"The appearance was suggestive of belladonna poisoning, but as there was no way of their obtaining that plant, we had to look elsewhere. The mother of one patient handed me a mushroom or toadstool which he had brought her, saying it was "good to eat berries." This looked like evidence of the infant's having eaten of this fungus. The other children, I learned subsequently, had been playing among the same fungi. What puzzles me is that I have always understood this class of poisons produced gastro-intestinal irritation, vomiting and purging. Not only were these symptoms absent, but it was extremely difficult to provoke vomiting. Happily, after a few hours the symptoms passed away, leaving no after effects."

This description was written on the 21st of September, 1905, and a week or two later, Mr. Peck wrote as follows:

"The specimens of mushroom sent are in my opinion a small form of *Psilocybe fœnisecii* (Pers.) Fr., called the Mowers' mushroom or Haymakers' mushroom. It is usually found growing among grass in meadows, pastures or lawns. I have eaten it when cooked and regard it as an edible species, having never experienced any ill effects from it. It is not pleasant in flavor when raw, and I would not think children would eat enough of it in the raw state to produce any ill effects."

This genus of fungi has purple-brown spores, but when old is not easily distinguished from others of similar habit such as

Panæolus which is black spored, and *Stropharia* which is reddish spored. The spores of the Glace Bay specimens were rather larger than the measurements given of *Psilocybe* by M. C. Cooke; so that it may not be identical with the species reported from elsewhere. Cook's measurements give the size about 10 x 6.25 microns, while those of our species varied from 13 x 8 to 14 x 9 microns. Again, although the cooked fungus might be safe, the uncooked might be deleterious. In order to stimulate the observation and recording of experiments on these fungi I report some of the observations already made on the genera referred to above. Of *Panæolus campanulatus* MacIlvane says:

"Mr. R. K. Macadam, Boston, Mass., informs me that he has information of a case of poisoning by this fungus. 'The victim experiences dizziness, dimness of vision, trembling and loss of power and memory. He recovered after simple treatment, and was well inside 24 hours.' A full account of this case is to be found in 'The London Medical and Surgical Journal,' vol. 36, Nov., 1816. The poison acts as a sedative. I have several times eaten of this fungus in small quantities, because larger could not be obtained, and with no other than pleasant effect. There does not appear to be any case of poisoning reported of it since 1816, which, considering the inquisitiveness of man, is singular. Caution is advised."

With respect to the nearly related species, *Panæolus papilionaceus,* MacIlvane says:

"The effects of eating this fungus are very uncertain. I have seen it produce hilarity in a few instances, and other mild symptoms of intoxication, which were soon over and with little reaction. Many personal testings have been made without effect. Testing upon others vary with the individuals. It is not dangerous, but should be eaten with caution. Being of small size, and not a prolific species, quantities of it are

difficult to obtain. Moderate quantities of it have no effect whatever."

Of the reddish spored *Stropharia,* he says:

"The entire genus has been under a cloud. Writers upon it assert some of its members to be dangerously poisonous. So far as carefully tested by the writer (MacIlvane) no doubtful species has been encountered, and one *(S. semiglobata)* has been eaten by himself and friends since 1881, notwithstanding its dangerous reputation."

It was Sowerby who drew attention to the above discussed species as dangerous, and intimated that in one case it had been fatal. A near relative of the Glace Bay species, *Psylocybe semilanceata,* a dark-purple spored agaric of the same general appearance, has its spores nearly of the same size. And, according to M. C. Cooke, a careful English authority, it has a dangerous reputation, having been said to have proved fatal to children when eaten raw. MacIlvane says it is not deleterious when cooked.

As there is much to learn yet about the effects of eating the different species of our fungi, it is hoped that all well attested experiences may be reported for publication and record. A fatal case of poisoning was reported from the neighborhood of Kentville the previous year; but the species were not known. The victim was an old man who had collected them for his supper, which it is presumed he had often done before. The symptons were those of *Amanita* poisoning, and the accidental inclusion of one specimen in the collection would have been sufficient to account for the results.

This case was thus described in a communication from W. B. Moore, M. D., on the 11th August, 1904:

"Mr. M., a farmer age 62 years, came home from his work late in the evening, apparently in good health, and very hungry. On his way home he hastily gathered a lot of mushrooms, and as hastily prepared them, with the assistance of his old wife

(no one else living in the house) for supper with meat, etc. He ate them all, the old lady not partaking, and soon afterwards developed marked symptoms of poisoning from an irritant and depressing agent. There was severe pain and distress in stomach and bowels, with vomiting and rapid exhaustion accompanied by abdominal distension, drawn features and haggard countenance with clammy and cold skin, subnormal temperature and cardiac failure, suppression of urine and paralysis of bowels. Although eliminative and supportive measures were used thoroughly it was impossible to prevent death, which occurred in about 33 hours from the time he ate the supper—apparently from paralysis of the heart from the effects of some toxic agent.

"Ptomaines might produce a similar train of symptoms, but there was no evidence to show that the food he ate had undergone any decomposition likely to produce poisonous alkaloids. I think the most reasonable assumption is that some poisonous fungus was included in the lot he gathered, although this cannot be proven as the fungi were eaten. The old lady could not give a clear idea of the different kinds which might have been present.

"I saw a somewhat similar case a few years ago, in which the man recovered; and in this case it was also impossible to demonstrate the kind or kinds of mushrooms eaten. As I have seen only these two cases during a period of more than twenty years in general practice, in a community in which large quantities of mushrooms are consumed, I assume that the poisonous fungi are few and far between in this region of the province; for I think there is doubtless much carelessness among people in the matter of selection."

Panæolus retirugis Fr. Edible, Middleton, RRG. Antigonish, JMS.

Panæolus campanulatus L. Lunenburg, MCH.

Coprinus comatus Fr. Middleton, RRG. Common throughout the province, and one of the most valuable edible species, AHMK. Lunenburg, MCH.

C. micaceus (Bull.) Fr. Middleton, RRG. New Glasgow, WPF.

C. plicatilis Fr. Lunenburg, MCH.

Cortinarius violaceus (L) Fr. Middleton, edible with an earthy flavor, RRG. Reported in "provisional list" from other parts of the province, AHMK.

C. albo-violaceus and *cinnamomeus*. Lunenburg, MCH.

Lactarius resimus Fr. Middleton, rather common in pine woods, RRG. Antigonish, JMS.

L. lignyotus Fr. Middleton, RRG. Pennant, Halifax, JS. The "bright crimson surface resembling fine silk plush" reported by Dr. John Somers and quoted in the "provisional list" of 1902, has not been observed by any other collector, and is supposed to be an accidental error.

L. vellereus Fr. Lunenburg, MCH.

L. piperatus Fr. Middleton, RRG.

L. subdulcis Fr. Middleton, extremely variable. RRG.

Russula heterophylla Fr. Dartmouth, AHMK. Shelburne, CSB. Lunenburg, MCH. MacIlvane has eaten specimens cooked repeatedly without harm. RRG.

R. adusta, depallens and alutacea. Lunenburg, MCH.

Cantharellus cibarius, *aurantiacus* and *floccosus*. Lunenburg, MCH; *cibarius*, New Glasgow, WPF.

Panus stypticus Fr. Middleton, common on stumps, tastes unpleasant in the throat, RRG. New Glasgow, WPF.

Schizophyllum commune Fr. Lunenburg, MCH. Middleton, RRG. New Glasgow, WPF.

Lenzites sepiaria Fr. Middleton, RRG. Lunenburg, MCH. *L. abietina* Fr. New Glasgow, WPF.

L. betulina Fr. Lunenburg, MCH.

Boletus cavipes Kalchb.—*(Boletinus pictus)*. Pt. Pl. Park, Halifax, AHMK; also at New Glasgow, WPF.

B. clintonianus, luteus, subluteus, edulis (claviceps). Lunenburg, MCH; also at New Glasgow, *americanus, granulatis, chrysanteron, chromapes* and *felleus*, WPF.

B. felleus Bull. Pt. Pl. Park, Halifax, spores 14-15 x 4 microns, AHMK.

Polyporus lucidus Fr. (*Ganoderma tsugæ* Murrill). Middleton, RRG. Lunenburg, MCH. New Glasgow, WPF; also *picipes*.

P. sulphureus Fr. Cow Bay, on decaying coniferous stump Halifax county, AHMK.

P. albellus Pk. Middleton, RRG.

P. fomentarius Fr. Middleton, common, RRG. Lunenburg, MCH. *(Coltricia,* Murrill). New Glasgow, WPF.

P. epileucus Fr. Lunenburg, MCH.

P. chioneus Fr. Middleton, RRG. Lunenburg, MCH.

P. applanatus Fr. Middleton, RRG. Lunenburg, MCH. New Glasgow and Pictou, WPF.

P. circinatus Fr. Middleton, RRG. Lunenburg, MCH.

P. betulinus Fr. Middleton, common on birch, RRG. New Glasgow, WPF.

P. elegans Fr. Lunenburg, MCH.

P. brumalis Fr. Middleton,RRG. Lunenburg, RRG. New Glasgow, WPF.

P. perennis Fr. and *cinnamomeus* (Jacq.) Sac. Lunenburg, MCH. (*Coltricia,* Murrill). New Glasgow, WPF.

P. versicolor Fr. *Polystictus versicolor,* Middleton, very common, RRG. Lunenburg, MCH.

P. abietinus Fr. Lunenburg, MCH.

P. hirsutus Fr. Middleton. RRG. Lunenburg, MCH. New Glasgow, WPF; also *pinicola* (Swartz) Fr., *pergamenus Fr., cinnabarinus, ignarius* and *Favolus europæus.*

Dædalia confragosa P. Lunenburg, MCH. New Glasgow, WPF; also *quercina* and *unicolor*.

Hydnum imbricatum L. Middleton, RRG. New Glasgow, WPF.

H. zonatum. Lunenburg, MCH.

H. repandum L. Middleton, RRG. Lunenburg, MCH.

Hydnum coralloides Scop. Mt. Thom, Pictou Co., on *Fagus ferruginea*, CLM. Lunenburg, MCH.

Stereum hirsutum Fr. Middleton, RRG.

Clavaria cinerea Bull. Middleton, RRG. Lunenburg, MCH.

C. botrytis, cristata, rugosa and stricta. Lunenburg, MCH.

C. aurea Schæff. Dartmouth, AHMK.

Clavaria coralloides L. Pictou, September, on ground, CLM.

Tremella lutescens Fr. Lunenburg, MCH.

Hirneola auricula-judæ Pk. New Glasgow, WPF.

Cyanophallus caninus Fr. Lunenburg, MCH.

Lycoperdon gemmatum Fr. Middleton, RRG. Pictou, LCH. Lunenburg, MCH. New Glasgow, WPF.

L. pyriforme Schæff. Lunenburg, MCH.

Scleroderma vulgare Fr. Lunenburg, MCH. New Glasgow, WPF.

Crucibulum vulgare Tul. On decaying trunks of deciduous trees, Pictou, CLM. New Glasgow, WPF.

Puccinia graminis Pers., *Ustilago tritici* Jen., *U. avenæ Jen.* New Glasgow, WPF. Pictou, on wheat and oats, CLM.

Ascophora mucedo Tode = *Mucor mucedo* L. = *Rhizopus nigricans* Ehrenb. (The common black mould of bread, &c.). Common, Halifax, Pictou, &c., AHMK, CHM, and WPF.

Morchella conica Pers. Middleton, RRG.

Gyromitra esculenta Fr. Middleton, common, May in sandy soil under pines, and reputed poisonous, RRG. Dartmouth, AHMK.

Mitrula vitellina Sac., var. *irregulare* Pk. Near Dartmouth, AHMK. Pictou, CLM. Lunenburg, MCH.

Spathularia velutipes Cook & Farlow. Middleton, RRG.

Leotia lubrica Pers. Lunenburg, MCH.

Peziza badia P. Middleton, RRG.

Hypomyces lactifluorum (Schw.) Tul. Middleton, common, RRG. Pictou, common, CLM.

Scorias spongiosa (Schw.) Fr. Specimen growing on alder found near Halifax by Mr. Harry Piers, within a few weeks ago, reported previously from Bedford Range and Yarmouth.

139.

TRANSACTIONS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1907-1908

ON A SKELETON OF A WHALE IN THE PROVINCIAL MUSEUM, HALIFAX, NOVA SCOTIA; WITH NOTES ON THE FOSSIL CETACEA OF NORTH AMERICA.—BY GEORGE H. PERKINS, PH. D., Professor of Geology, University of Vermont, State Geologist of Vermont, Burlington, Vt.

(Received for publication 29th July, 1908.)

Skeleton of a Whale from Jacquet River, New Brunswick.

In the *Transactions of the Nova Scotian Institute of Science,* vol. ii., pp. 400-404, 1873, Dr. J. Bernard Gilpin published "Observations on some Fossil Bones found in New Brunswick." In course of a study of the fossil cetacea of North America, the attention of the author was directed to the above article, and learning that the bones described by Dr. Gilpin were preserved in the Provincial Museum of Nova Scotia, at Halifax, enquiries concerning them were sent to Mr. Harry Piers, the curator, and by his courtesy the specimens were sent from Halifax in order that they might be carefully studied and compared with the skeleton of the Vermont specimen with which the Canadian bones had been considered identical.

The account written by Dr. Gilpin is brief and without illustration, and he had no similar bones with which he could

compare those in which he was especially interested. Hence it will not, it is hoped, appear an unnecessary undertaking to give a full description with illustrations of different bones, of this very valuable and interesting specimen.

The bones described by Dr. Gilpin were found in a cutting of the Intercolonial Railway on the Jacquet River, Bay de Chaleurs, New Brunswick. "After cutting through about twelve feet of sand and gravel a bed of clay was reached. In this the bones were bedded." Numerous shells common in Pleistocene deposits, as *Saxicava, Mya, Macoma,* occurred in the clay.

There came to the writer from the Halifax museum twenty-three bones, namely: two fragments of the basioccipital, both scapulas, though considerably broken, one periotic, the sternum, four dorsal vertebræ, five lumbar vertebræ, eight caudal vertebræ. Dr. Gilpin mentions "a small portion of the atlas, twelve fragments of the skull, about one half of a lower jaw, one humerus, radius, ulna, phalanx," in addition to those named above. These bones appear to have been mislaid. At any rate they were not among those which I received. All the bones are chalky, brittle, and more or less broken. Of the total skeleton, the following bones are represented:

The Periotic.—The left periotic is all that was found of the ear bones. This bone has, as the lower figures on plate I show, the usual irregular form. This can be better appreciated by examination of the figures than by any verbal description. It is shown in the figures of natural size.

No other bones of the head, except two fragments from the base of the skull were among those sent. It is especially unfortunate that more of the cranium was not found, for, as will appear later, if we could have the front part of the rostrum it would be easy to determine with absolute certainty at least the genus of this specimen.

Vertebræ.—It should be noticed that plate II shows the vertebræ that were sent, very much reduced, except one, that would have been the last, accidentally omitted by the photographer, arranged as nearly as possible in their natural position; but as more than half of the series are missing, the order must at best be much broken.

As will be seen, all are more or less imperfect as to the processes. The centra are in very good condition. In only two is the neural arch complete, and only one neural spine remains. The transverse processes, though badly broken, have fared somewhat better, and five or six of them are sufficiently whole to indicate fairly well their original form. As would be expected from the different form of the caudals, the above remarks do not apply to the last three or four in the plate. No *cervicals* have been seen and the first four or five dorsals are also wanting.

Dorsal vertebræ.—There are four dorsal vertebræ present. That placed first is undoubtedly one of the anterior bones of the series, but, as indicated, not one of the first. This is shown by the evident carina on the under side.

As shown in the top figure, plate III, the neural arch is complete, but the transverse processes are nearly gone. On plate III, this and other vertebræ are shown about one-third natural size. From comparison with skeletons of recent individuals, it is inferred that this bone was about the fifth or sixth in the dorsal series.

The body, or centrum, is somewhat concave above and distinctly carinated below. It is, measured anteriorly, as are all that follow, 60mm. ($2\frac{3}{8}$ inches) wide, 52mm. (2 inches) high, and 65mm. (2 9-16 inches) long. In this the neural canal is much larger than in any of the vertebræ that follow. It is 48mm. ($1\frac{7}{8}$ inch) high, and 73mm. ($2\frac{7}{8}$ inches) wide. The

ends of the centrum are nearly flat, the posterior slightly concave.

The following vertebræ are probably nearer the end of the series, as it appears that between first and second, in the figure, three or four bones are wanting.

As the figures show, in the second vertebra, the neural arch is quite destroyed, but the left transverse process is in very good condition. The centrum is much heavier than in the first. Its dimensions are:—length 72mm. (2 15-16 inches), width 65mm. ($2\frac{1}{2}$ inches), height 60mm. (2 5-16 inches), neural canal 70mm. ($2\frac{3}{4}$ inches) wide.

The transverse process is stout, much thickened at the end, flat above, convex below. It is nearly perfect, and is 76mm. (3 inches) long, 32mm. ($1\frac{1}{4}$ inches) wide next the centrum, and 51mm. (2 inches) wide and 25mm. (1 inch) thick at the end. This bone is shown in plate IV, upper figure. In the third bone, which is probably the eighth or ninth dorsal, we have perhaps the most complete of the series. The neural arch and transverse processes are fairly complete, as the figures show. The centrum of this vertebra is 61mm. ($2\frac{3}{8}$ inches) high, 70mm. ($2\frac{3}{4}$ inches) wide, and 76 mm. (3 inches) long; the neural canal is 37mm. high, and 57mm. wide. The left transverse process, which is most complete, is 92mm. long. The last dorsal in the specimen, fourth of 1st series of plate II, is perhaps the eleventh. The centrum, especially beneath, has the characters of the lumbars. It is 65mm. ($2\frac{1}{2}$ inches) high, 70mm. ($2\frac{3}{4}$ inches) wide, and 82mm. ($3\frac{1}{4}$ inches) long. The left transverse process is quite complete, and shows all the features of that part of the bone. It is 121mm. ($4\frac{3}{4}$ inches) long.

Lumbar vertebræ.—In the absence of chevrons it is difficult to determine the point where the lumbars pass into the caudals, but five of the bones are considered as lumbar. The bodies lengthen and the vertical diameter increases towards the caudal

end. All have a strong inferior carina, but it decreases towards the caudal end.

The first vertebra of the second set, plate II, appears to belong to the anterior portion of the series, third or fourth. The centrum is 68mm. ($2\frac{5}{8}$ inches) high, 71mm. ($2\frac{3}{4}$ inches) wide, and 85mm. ($3\frac{3}{8}$ nches) long. As in all lumbars, the transverse processes are, compared with the dorsal, thin and flat. All are so broken that it is not possible to ascertain the length with exactness.

The most typical cetacean lumbar is that shown in the third figure from the top in plate IV. This is more perfect than the other lumbars, and the left transverse process is nearly complete. It is the only process that shows the widened ends found normally in all these vertebræ. This was probably the third or fourth in the actual series. The measurements are as follows: height of centrum 69mm. ($2\frac{3}{4}$ inches), width 71mm. (2 13-16 inches), length 87mm. ($3\frac{1}{2}$ inches). The transverse process is 114mm. ($4\frac{1}{2}$ inches) long, and 60mm. ($2\frac{3}{8}$ inches) wide at the end. The length was originally slightly greater, as the end is somewhat broken. In all cetacea the spines of the lumbars are very long, and were these present in this specimen they would give a different aspect to the series. The remaining lumbars do not offer any essential differences. That which appears to be the last, has the centrum rather more nearly circular, the width being only a little more than the height, and the neural canal is considerably less, its width being 35mm. ($1\frac{3}{8}$ inches).

Caudal vertebræ.—The eight remaining vertebræ are considered caudal. As the lower series, plate II, indicates, there is much difference between the first and the last lower right hand figure, plate IV. The whole series of caudals, except one as stated before, is shown in plate II, lower series. If there were originally twenty-six caudals, of course this series must be very incomplete.

As we have them, the changes may be in some measure noted by a study of the bodies which increase in size to the fourth of the series, and then suddenly decrease. There are evidently several vertebræ missing between the third and fourth vertebræ, plate II.

In the third the body is larger than in any other of the whole series. Here also the spine has an entirely different form from that found in the preceding bones. It is not only shorter, and relatively broader, but, as may be seen in plates II and IV, there are short, blunt metapophyses. The centrum here has a height of 87mm. ($3\frac{1}{2}$ inches), a width of 83mm. ($3\frac{1}{4}$ inches), and a length of 95mm. ($3\frac{3}{4}$ inches). The neural canal, however, is reduced to a width of only 10mm., or a seventh of that in the first vertebra mentioned. The transverse processes are also reduced to mere ridges, and they soon grow so small as to be hardly noticeable, and in the last have nearly disappeared.

As seen, though not as distinctly as might be desired, there is a backward projection from the spine in *h* so that the whole ridge, rather than process, is as long as the body. In the caudal last on plate IV, the body is nearly circular. None of the button or discoid vertebræ, such as always form the final portion of the tail, are present. Apparently, there should be at least twelve after the last shown in plate II. The caudal that was accidentally left out when the bones were photographed as seen in plate II, is seen in the last plate IV.

As stated, there were probably twenty-six caudals originally. If twelve of the eighteen missing bones should come after the last in plate II, then six should be placed between the third and fourth of the last series in plate II, or at any rate in that region.

Chevrons.—No chevrons were with the bones received from the Halifax museum. In the plate of the skeleton of *Monodon,* Van Beneden and Gervais (*Osteographie des Cetaces*) there are fourteen chevrons.

When laid in continuous series, as in plate II, the vertebræ measure 135 cent. (55 inches) in length. Of course this leaves out all intervertebral cartillages which would add materially to the total length of the column. The whole of the cervicals and the head are also to be added to complete the original length.

As far as it has been possible to determine by comparison with skeletons from recent specimens, the Halifax whale was not far from twelve feet long when living. This corresponds well enough with measurements of recent individuals. If this specimen should be referred to Monodon, as I have little doubt twelve feet would be a fair length for a medium-sized specimen.

The following table of measurements of the different vertebræ will not be without interest to one who may wish to make a thorough examination of the specimen. All the measurements were made at the anterior face of each vertebra:

Measurements of the vertebræ of the Halifax whale.

	Length of body.	Width of body.	Height of body.	Width of neural canal.
		DORSALS.		
a	65mm.	60mm.	52mm.	73mm.
b	72mm.	70mm.	60mm.	70mm.
c	76mm.	70mm.	61mm.	57mm.
d	82mm.	70mm.	65mm.	48mm.
		LUMBARS.		
e	85mm.	71mm.	68mm.	48mm.
f	87mm.	71mm.	69mm.	43mm.
g	90mm.	73mm.	73mm.	40mm.
h	90mm.	75mm.	74mm.	37mm.
i	93mm.	76mm.	75mm.	35mm.
		CAUDALS.		
j	93mm.	78mm.	76mm.	32mm.
k	93mm.	81mm.	77mm.	25mm.
l	94mm.	83mm.	77mm.	22mm.
m	95mm.	87mm.	80mm.	10mm.
n	69mm.	85mm.	83mm.	10mm.
o	66mm.	77mm.	83mm.	8mm.
p	56mm.	65mm.	70mm.	5mm.
q	49mm.	62mm.	70mm.	4mm.

In discussing individual vertebræ, many of the resemblances and differences existing between them have been noticed. A few additional points may be mentioned.

The centra vary slightly from vertebra to vertebra. This may be seen in plates III and IV, if different figures are compared. It will be seen that the form changes as we pass from the anterior dorsals back. This is better seen if the table of measurements be examined. Here it will be found that the length of the body increases from the beginning back to the 13th, of the series as given in plate II. The great diminution between the 13th and 14th indicates that several bones are lacking, but from the 13th the length of the body decreases rapidly, and had we the final caudals, the shortening of the bodies would be still more apparent. The width of the centra increase up to the same vertebra, while the height increases beyond to the last but one, and from here is a rapid decrease. That is to say, the centrum of each vertebra is wider than high to and including the 14th of the fossil series. In the next vertebra the width is considerably less than the height, and so remains in the rest of the series.

The neural canal is largest at the beginning, top figure, plate III. Here it is broadly oval, much wider than high, but in *c*, which, unfortunately, is the only other vertebra in which both height and breadth can be measured, until we go back nearly to the end of the caudals, the width is reduced to from 73mm. to 57mm., and the height 73mm. to 38mm., and so on until in the last caudal we have it only 4mm. wide and about the same in height.

Sternum.—This bone is very thick and large, and, in the fossil, spongy in texture. As plate I shows, its general outline is triangular. The segments are entirely anchylosed so that no trace of sutures remains. Although the bone is not perfect, as will readily be seen, still enough remains to supply a fair indication of its complete form. Articular surfaces for

three ribs are plainly seen, but those for the remaining three cannot be well made out. It is reduced one-half in plate I.

While on account of the condition of the bone, exact measurements cannot be made, yet it may be well to notice that as we have it, the total length is 229mm. (9 inches), width across the upper end 191mm. ($7\frac{1}{2}$ inches), width across the articular spaces at the lower end, 83mm. ($3\frac{1}{4}$ inches), thickness at the upper part 38mm. ($1\frac{1}{2}$ inches), average thickness rather more than 18mm. ($\frac{3}{4}$ inch). The whole bone is somewhat curved longitudinally.

Scapula.—Both scapulas were preserved, but in a much broken condition, so much so that the original form cannot be made out. It is, however, most probable that these bones had the same form as in recent specimens of *Monodon.* They appear to have been thin and thus easily broken. A considerable part of the glenoid cavity is present in each scapula.

Specific position.—In Dr. Gilpin's account of this specimen we find the following, "The fragment of the lower jaw so exactly resembles the cut in Dana's *Geology,* of *Beluga vermontana,* as to hazard the conjecture that they are closely allied if not identical." Students of anatomy do not need to be told that this is very slight foundation for regarding the two specimens as of the same or allied species. Dr. Gilpin's account was published in 1873, and since then, the Halifax specimen has been assumed to be the same as Thompson's Vermont specimen.

After the bones were received from the Halifax museum they were compared with those of the Vermont specimen, and it soon became evident that the two were in important respects unlike. Had the Halifax specimen been as complete as is the Vermont, it is certain that the differences would have been more numerous and more marked.

Very fortunately, there is one periotic with each skeleton, and thus we can compare what is probably the most important

bones of all for specific identification. Plates I and VIII show these, and the dissimilarity must be evident to anyone who examines them with care.

The sternum in the Halifax whale also presents important differences from that of the Vermont one, as plates I and VII show. The various vertebræ in each skeleton present greater or less differences.

It is perhaps unnecessary to go into a detailed comparison of the two sets of bones. It will be sufficient if a few of the more important points are mentioned.

As will be seen by comparing the sternums of the two whales, there is a marked dissimilarity in the form. It should be stated here that the two are not shown in the plates on the same scale, hence this must be taken into account in comparing them. The Halifax sternum is shown on plate I a little less than half, exactly 4-9ths, natural size; while the sternum of the Vermont whale, as shown in plate VII, is one-third natural size. It will be noticed that the Halifax specimen is much wider relatively across the top, and tapers more rapidly from the top down, and it is thicker at the top than is the Vermont specimen. The latter is probably longer; but the lower end of the Halifax bone is broken, so that its actual length cannot be ascertained.

As to the more important bone, the periotic, I am happy to be able to quote the opinions of others who are much better able to decide questions in cetacean anatomy than the author. After examination of photographs of the Halifax periotic, Dr. F. W. True wrote as follows: " As regards the Nova Scotia specimen, I think that there is no doubt that it is not *Delphinapterus,* on account of the shape of the periotic and short lumbar vertebræ. Our skulls of *Monodon,* unfortunately, are without the periotics so that I cannot make comparisons of importance, but Van Beneden's and Gervais' figures indicate a shape similar to that shown in your photographs." Much to my regret I could not

show the actual bone to Dr. True, but at the time of my visit to the American Museum in New York, I had the bone and was able to leave it with Mr. Andrews, who later wrote concerning it: "I have just finished a comparison of the periotic bone which you sent with that of *Delphinapterus leucas* and of *Monodon monoceros*. As soon as I looked at the periotic of this specimen, it seemed to resemble very closely the corresponding bone of *Monodon*. A comparison shows that in size and general shape it agrees very much better with *M. monoceros* than with *D. leucas*. In fact the whole shape of the bone is decidedly unlike *Delphinapterus*. In order to verify my opinion, I showed the specimen to Dr. W. D. Matthews, and he agreed with me that while there are some points of difference between the periotic of this specimen and that of *Monodon*, yet it is certainly closer to that genus than to *Delphinapterus*. Your specimen, on the other hand, agrees well with *Delphinapterus*, consequently it would seem to me unlikely that it and the Halifax whale can be of the same species or even the same genus. . . . . The tympanic and periotic are, so far as I am aware, subject to less individual variation than any other bones in the cetacean skeleton, and the remarkable difference shown in the Halifax whale would seem a pretty good ground for a close examination of the species if it has been referred to *Delphinapterus*. Of course if you could see the rostrum of the Halifax specimen and determine whether or not the upper teeth were present, it would simplify matters very greatly, for *Monodon* has no teeth aside from the tusk." The above is, I think, conclusive as to placing the Halifax specimen in the genus *Monodon*.

Only a single living species of this genus is recognized by any of the authorities. Whether the fossil specimen is to be referred to the living speciese, or should be placed in a species by itself, cannot well be settled from the material in hand. Undoubtedly, the fossil bones are very much like corresponding

bones in the living species. I have compared them with specimens in the American Museum at New York, and, while some differences certainly do appear, yet it seems to me that on the whole it would not be wise to create a new species where there is so close similarity.

Nicholson and Lyddeker, *Manual of Palaeontclogy,* page 1307, say: "Remains of Narwhal, *Monodon monoceros,* are found in the Norfolk Forest bed and the Pleistocene of Alaska."

At present, *Mcnodon* has been, though rarely, taken as far south as England. *Monodon* and *Delphinapterus* are closely allied species, and Flower, *Trans. Zoological Society,* London, 1886, placed these two genera in a group, *Belugineæ,* which includes no others.

Notes on fossil cetacea of North America.

It may add to the value of this article if a few notes on other fossil cetaceans are included. This is the more true because nearly all the specimens of this order that have been found have occurred in Canada. One of the most perfect skeletons is that described by Thompson from Vermont, and, with the possible exception of a few isolated bones, this is the only specimen that has been found in the United States. The following is, so far as I can ascertain, a list of all the specimens thus far discovered:

I.—1849. A nearly complete skeleton; Charlotte, Vermont; Professor Z. Thompson. State Museum, Montpelier, Vermont.

II.—1858. Several caudal vertebræ; Mile-end Quarries, Montreal; Sir W. Logan. Museum of the Geological Survey, Ottawa.

III.—1864. A few bones; Riviere du Loup, Ont.; Sir J. W. Dawson. Peter Redpath Museum, Montreal.

IV.—1870. A nearly complete skeleton; Cornwall, Ont.; Mr. E. Billings. Geological Survey Museum, Ottawa.

V.—1874. A considerable portion of a skeleton; Jacquet River, N. B.; Dr. J. B. Gilpin. Provincial Museum, Halifax, N. S.

VI.—1883. A few vertebræ and fragment of a rib; Smith's Falls, Ont.; Sir J. W. Dawson. Redpath Museum.

VII.—1891. A portion of the lower jaw of a large whale; Metis, Quebec; Sir J. W. Dawson. Redpath Museum.

VIII.—1895. A nearly complete skeleton; Smith's brickyard, Montreal; Sir J. W. Dawson, Redpath Museum, Montreal.

IX.—1901. A hyoid, ribs and other bones; Williamstown, Ont.; Mr. E. Ardsley. Redpath Museum.

X.—1901. Several vertebræ, ribs and parts of cranium; Smith's brickyard, Montreal. Redpath Museum.

XI.—1906. Most of the skull, several vertebræ; Pakenham, Ont.; Dr. J. F. Whiteaves. Not in a museum.

The following notes on the above specimens may not be without value to those who have not ready access to the skeletons themselves. With the exception of the Pakenham specimen, the author has examined all the specimens named in the list. Hearty acknowledgments are due Mr. Harry Piers, Provincial Museum, Halifax, N. S.; Mr. Edward Ardsley, of the Peter Redpath Museum; Dr. Whiteaves and Mr. Lambe of the museum of the Geological Survey of Canada, Ottawa, for freely giving all possible aid in the examination of the specimens in those museums.

I.—The Vermont specimen, plates V-VIII, has been longest known and has often been considered as the type to which most of the others since discovered have been referred. For this reason, as well as for the sake of adding completeness to this paper, a somewhat full account of this historic specimen may be given in this connection. Plate V shows this specimen as now mounted in the Vermont museum. Very unfortunately, the mounting was not done by an anatomist, and most of the

vertebræ back of the dorsals are reversed. The cranium was badly shattered when found, and was restored in some respects very satisfactorily, but in others quite erroneously. The mounting was done some fifty or more years ago, and the bones are so easily broken, though much less fragile than those of the Halifax specimen, and the rods used in mounting the separate bones have so rusted that, while the curator hopes at some time to remount the skeleton, he has not as yet ventured to undertake the task.

In the plate the upper figure shows the entire skeleton reduced to about one-fourteenth natural size, and the two lower show most of the vertebræ reduced to about one-third natural size.

Those interested in cetacean anatomy will find it profitable to compare plate V with plate II, which shows the vertebræ of the Halifax specimen. Like most of the remains of cetacea found in pleistocene deposits, the Vermont specimen was discovered in a bed of clay, "between eight and nine feet below the surface," in a railroad cut. They were secured by Professor Z. Thompson, who studied and described them, but with very poor illustrations, and after considerable deliberation placed the animal in a new species, believing, and as recent investigations show rightly, that while very closely allied to the living white whale, *Delphinapterus leucas,* it nevertheless presented differences of sufficient importance to warrant its separation specifically from the living form.

The following named bones were found and are now preserved in this skeleton. The cranium was badly broken, but enough fragments that could be pieced together were found to, as Thompson says, "determine very nearly the form and entire length of the head and of one side of the lower jaw, and of its symphysis with the other side."

From the alveoli it appears that the animal had seven teeth in the lower jaw and eight in the upper on each side, or thirty in all. Only nine of these were found. Forty-one vertebræ

were found, four cervical, eleven dorsal, ten lumbar and sixteen caudal. Five of the chevrons were saved, the right periotic, sternum, hyoid, both of which are large and heavy, the scapulas, one humerus, both ulnas, one radius, more or less complete portions of nine pairs of ribs and fragments of others. Thus while somewhat less complete than either the Smith's brickyard or the Cornwall specimen, a large majority of the bones have been preserved in the Vermont specimen, including some, as the periotics, not found in the others.

II.—The bones discovered in 1858 in the clay near Montreal, are now in the museum of the Geological Survey at Ottawa. They are mostly caudal vertebræ, but there are several lumbars among them. In all there are twenty vertebræ. Thus a considerable portion of the caudal series is present. Probably not more than five or six are wanting. The spines, neural arches and transverse processes in most are present. Of course these are smaller and stouter in the caudals, after the first few, than elsewhere, and would therefore be more likely to withstand unfavorable conditions. These processes are, however, more or less incomplete in all. These vertebræ do not differ essentially in size or form from those in the Cornwall specimen. As now mounted with the intervertebral cartilages supplied by wooden disks, the total length of the series is sixty-five inches.

In "Superficial Geology of Canada," Geological Survey, Canada, page 919, Sir W. Logan says, "At the mile-end quarries, Montreal, upon a slight ridge are found stratified sand and gravel holding boulders and shells in the lower part. The deposit sometimes rests directly on the limestone rock, which is at other times covered with a thin layer of boulder formation. . . . A thick deposit of this clay is seen at the brick-yard of Messrs. Peel and Comte, where it is overlaid by Saxicava sand, and has furnished one of the pelvic bones of a seal, and several of the caudal vertebræ of a cetacean, *Beluga vermontana,* besides fragments of white cedar."

III.—In the Riviere du Loup specimen there are preserved only a portion of the atlas and one caudal vertebra which is one of the posterior portion of the series.

IV.—This is a very fine and nearly complete skeleton. It is well mounted and is in the Ottawa Geological Survey Museum.

For a copy of the following account by Mr. E. Billings, I am indebted to Dr. Whiteaves. "Several months ago, Mr. Charles Poole, of Cornwall, wrote to the secretary of the society that a large skeleton, resembling that of *Ichthyosaurus,* had been found in the neighborhood, by the men engaged in excavating clay for brick. In another letter he stated that Mr. T. S. Scott had procured the lower jaws, and states that Mr. Scott presented the jaws to the geological museum." Mr. Billings then went to Cornwall and obtained from Mr. Poole the bones which were in his possession. "These were discovered in Post-pliocene clay about sixteen feet below the surface. They are those of a small whale closely allied to the white whale, *Beluga leucas,* which lives in the northern seas, and at certain seasons abounds in the Gulf of St. Lawrence. The lower jaws are nearly perfect. The skull and upper jaws are much damaged and some of the parts lost. Thirty-five of the vertebræ, the two shoulder blades, most of the ribs, and a number of small bones were collected. The length of the animal was probably about fifteen feet. The lower jaws have the sockets of eight teeth upon the right side and seven on the left." E. Billings, *Canadian Naturalist and Quarterly Journal of Science,* vol. v., pp. 438-9.

Some of the parts of this skeleton are more perfect than in any other that has been found; but taken all in all, this and the best specimen in the Montreal museum are about equal, and both rather more perfect than the Vermont specimen. However, each has some portions that are lacking in the others.

As mounted in the Ottawa museum the Cornwall whale is twelve feet and one inch long. The cartilages have been sup-

plied by wooden disks. There are present the following parts: The cranium is tolerably complete, but broken at the rostral end and also in the occipital region. Measured in a straight line from the front of lower jaw, which being perfect locates the missing part of the rostrum, the upper jaw being broken at the end, to the lower part of the foramen, the length is twenty-one inches, and nine and a half across the condylar region. There are no teeth, but alveoli for eight on each side of the upper and right side of lower jaw, while on the left side of the latter, there are only seven alveoli. No ear bones were found. The hyoid and one stylohal are present.

There are thirty-eight vertebræ, viz., all the seven cervicals, ten dorsal, ten lumbar, eleven caudal and one chevron. In all but four, the spines are complete, and nearly so in one of these. The neural arch is seen in all but two. The transverse processes are present in all, but in all are more or less broken, though not badly in many. The bodies increase in length from the cervicals backwards to the tenth lumbar. In the cervical behind the axis the length of the body is one-half inch, and in the largest it is four and a quarter inches.

Probably not less than thirteen caudals are wanting from the end of the column.

The scapulas are not only both present, but are in excellent condition. Each is somewhat broken on the border, but as they are not broken in the same part it is possible by taking them together to make out the entire outline. Even the very long and slender coracoids are perfect. Each bone measures from the top border to the glenoid border eight inches, and ten inches across the upper border. The coracoids are nearly ten inches long on the upper border.

The humerus, like all the arm bones, is rather short and stout. It is five and a half inches long; the radius is three and a half, and the ulna four and a quarter inches.

There are ten ribs on the right side and nine on the left. Some of them are considerably broken, but others are nearly perfect. The longest in this skeleton is the fifth, which from vertebra to sternum, is thirty-five inches on the outside curve. This specimen is more perfect than any other in its vertebræ and scapulas.

V.—This is the Halifax specimen, which is described in the first part of this paper.

VI.—In *American Journal of Science,* 3rd series, vol. xxv., p. 200, Dr. Dawson writes: "Bones of large whales are not of infrequent occurrence in the lower St. Lawrence. . The bones found on lower and therefore modern terraces are usually in a good state of preservation, and have a very recent appearance." After mentioning several specimens of "Beluga," all of which are discussed in these pages, Dr. Dawson mentions particularly several large bones found in a gravel pit thirty feet below the surface.

In *Canadian Ice Age,* p. 268, Dr. Dawson refers to these bones as follows: "*Megaptera longimana,* Gray. Portions of a skeleton of this species were found in 1882 in a ballast pit of the Canadian Pacific Railroad, three miles north of Smith's Falls, Ontario, 31 miles north of the St. Lawrence River. They were imbedded in gravel along with shells of *Tellina grœnlandica,* apparently on a beach of the Pleistocene period, at an elevation of 440 feet above the sea, which corresponds nearly with one of the principal sea-coast terraces on the Montreal mountain and other parts of the St. Lawrence valley."

These bones, now in the Redpath Museum, consist of a dorsal, a lumbar vertebra, part of the neural arch of another, and a part of a rib. The centrum of the lumbar is ten inches in diameter and from tip to tip of the transverse processes it is thirty inches.

The bones have a much fresher appearance than those of the other fossils here recorded. Dr. Dawson says of these: "I have no doubt that they belong to the Humpback Whale, *Megaptera longimanas* (*boops*).

VII.—In *Canadian Ice Age*, page 269, Dr. Dawson writes: "I secured last summer, 1891, a large jaw-bone found in digging a cellar in the shelly gravel of the lower terrace at Metis." This fragment, for the interior portion is wanting, is over eleven feet long and eighteen inches wide near the articular end.

VIII.—This is one of the finest of our fossil cetacea. It includes nearly all the bones of the skeleton, and most of them are in very good preservation.

The cranium is better in this than in either the Ottawa or the Vermont specimen, although it lacks ear bones. The lower jaw is less perfect. The hyoid, one stylohyal and part of the other are present. Nine teeth are preserved in the upper jaw and two in the lower. Both scapulas and all the arm bones are present, but no phalanges. There is also a considerable part of the sternum.

In all, thirty-six vertebræ are seen in the skeleton. These are all the cervicals, ten dorsals, ten lumbars and nine caudals. There are no chevrons. Most of the vertebræ are essentially complete. All except two have at least a part of the neural arch and spine, and in most these are in good condition. The transverse processes are all, at least partially, present, but most are somewhat fractured. The last of the caudals are missing, and a few which would come in between those mounted in the specimen. The whole are exceedingly well set up and accurately placed. The ribs are in fairly good condition.

The missing cartilages have not been supplied in this specimen. As it is mounted, it is one hundred and twelve inches long.

IX.—A few bones consisting of the hyoid, sternum, nearly complete, several phalanges and some fragments of ribs were found by Mr. Edward Ardsley at Williamstown, Ontario, in 1901. This find is especially interesting as giving the only phalanges we have in the fossil skeletons.

X.—In the same clays in which the complete skeleton was discovered at Smith's brickyard, Montreal, a number of bones of a young individual were found. There are ten vertebræ, apparently mostly caudals, though some are lumbars. In all, the apophyses are separated from the centra of the vertebræ, but were secured with the rest.

All the bones are small, the largest centrum being one and three-fourths inch in diameter. The bones indicate an immature animal, but more than half grown. Besides the vertebræ there are five parts of ribs and portions of the cranium.

XI.—Most of the skull and a number of vertebræ found at Pakenham, Ontario. Not placed in a museum, but presumably in the possession of Mr. Patrick Cannon, of Pakenham. Of this Dr. Whiteaves writes in the *Ottawa Naturalist,* vol. xx, pp. 214-216, as follows: "On the fifth of September, 1906, a skeleton, which is obviously that of a very young individual of white whale, was found by Mr. Patrick Cannon while digging a well on his farm at Pakenham, Ontario. . . . . This skeleton was imbedded in blue clay, fourteen feet below the surface, and only a portion was dug out. In digging the well, some depth of clay was first bored through, then a mixture of clay and shells, in which the skeleton was found, was struck, and the excavation ended in blue clay. The bones that have been exhumed so far consist of a nearly perfect skull, with only a few of the teeth missing, and one of the tympanic bones with most of the cervical vertebræ and three of the dorsals with some of their epiphyses. Apart from the obvious immaturity, this Pakenham skull and the vertebræ immediately adjoining

thereto seem to be essentially similar to the corresponding parts of the skeleton of the *Beluga* from Cornwall Pleistocene and that of a recent specimen of the white whale from Metis in the museum of the survey."

In *Bulletin 179, U. S. Geological Survey,* Mr. O. P. Hay enumerates seventy-eight species of fossil cetacea. Most of these species are not now living. Of the whole number, forty-three are found in the Miocene, eleven in the Eocene, seventeen in the Tertiary, epoch not stated, and six in the Pleistocene. There is one species not assigned. Of the six Pleistocene species, one found in Louisiana is a doubtful fossil, *Physeter macrocephalus.* Another, *Physeter vetus,* is from South Carolina, one from Vermont, *Delphinapterus vermontanus,* one from Alaska, *Monodon monoceros,* two from Canada, *Delphinapterus leucas* and *Megaptera boops.* To the above should be added the Halifax specimen, that from Pakenham, and sundry isolated bones found in Canada, all of which are given in the foregoing list.

As many of the references given show, nearly all of the Canadian specimens have been referred, by those geologists who have had occasion to mention them, either to the living *Delphinapterus leucas* or to Thompson's *D. vermontanus,* mostly to the former.

In those specimens which are very imperfect, it is not possible to determine as to the correctness of these identifications, since the resemblances, which always exist in most of the bones of allied species of cetacea, are so close as to render separation useless. This would be emphatically true when only a few vertebræ were found. When the periotic is present it should be possible to come to more satisfactory conclusions.

Dr. Dawson says that the Cornwall specimen was compared by Mr. Billings with recent bones of *D. leucas,* and as a result of this comparison Mr. Billings "concluded that it belonged to the modern species, and I believe extended his conclusion to Mr.

Thompson's specimen." So far as appears, Mr. Billings had never seen the Vermont specimen, at least had not studied it. Dr. Whiteaves writes: "The identification of the Mile-end specimen, and of that from Cornwall, with *Beluga vermontana,* it must be remembered, is solely on the authority of Mr. Billings. It seems to me that the specimens from those two localities and the skull, etc., from Pakenham, which are all that I have seen, are at any rate all referable to the same species. And I do not see how they are to be distinguished from the present *D. leucas.*"

The question whether the Vermont specimen is as Thompson decided, a new species or *leucas,* has usually been decided by writers in favor of the living species. Thompson's reasons for separating it from *leucas* were, a difference in dentition, in size of maxillary bones and some minor points. None of these are sufficient, considering the individual variation within the same species of many cetacea. As has been previously noticed, the periotic is less likely to vary in different individuals of the same species than any other bone. After a study of this bone, Mr. Andrews writes, "I have compared the bone with the ear-bones of several specimens of *Delphinapterus leucas.* The resemblance, except in size, is very close indeed. The bullate portion of the periotic in your specimen is somewhat smaller in proportion to the whole length than in *Delphinapterus leucas.* The internal auditory meatus is also slightly different in shape. However, I believe that these characters are open to a slight individual variation. The difference in size seems to me an important one, as it probably indicates that your animal, if adult, is a smaller animal than *Delphinapterus leucas.* A comparison with the periotic of a very young individual of *Delphinapterus leucas* shows this bone in the latter to be considerably larger than in your specimen."

The author visited the American Museum, New York, twice for the purpose of comparing the fossil bones with those of recent skeletons, and then went to the National Museum, Wash-

ington, for the same purpose. Here Dr. True was most helpful, as has already been noted. A series of photographs of the periotic of the Vermont specimen was examined by him, and he reports as follows: "The periotic of *D. vermontanus* appears to indicate that the species is distinct from *leucas.* The principal differences are that in the former the petrosal is larger, the porus acusticus internus also larger and differently shaped, the posterior process of the petrous portion much longer and more pointed, the anterior process more rounded, the fenestra cochleæ larger. I cannot see that the vertebræ of *vermontanus* present any tangible differences of importance. The neural arch of the axis appears to be differently shaped, but this is probably due to its imperfect condition. The vertical foramina in the sides of the centra of the caudals appear smaller, but there is considerable variation in this character. The coracoid process of the scapula is narrow at the end, but this is also variable. I think the ulna is straighter. It is really necessary in identifying such material to examine the specimens themselves."

As to what Dr. True notices in respect to the neural arch of the axis, it may be well to say that this vertebra in the Vermont specimen does not seem to have been broken to any such extent as to change its form, especially that of the upper border of the spine, from that of *D. leucas* to that which it now has. In all specimens of the recent species which I have seen, the upper portion of the spine slopes rapidly from back down to the front, while in *D. vermontanus* it is nearly horizontal, that is, it has little slant from the back to the front edge.

The hyoid, too, is much more cylindrical in the thyrohyal portion. Of course it may be said that most or all of these characters are subject to individual variation in the cetacea, but allowing for this it seems probable that some at least of these characters are constant and may be regarded as at least varietal if not specific. It appears, then, that Thompson was justified in establishing the species *vermontanus.*

After a somewhat careful study of all the different specimens given in the foregoing list, the following conclusions have been reached by the author as to the specific position which should be occupied by these specimens. Very fortunately, in both the Redpath Museum and that at Ottawa there was a well-mounted skeleton of *D. leucas* close at hand, so that comparisons were readily made. As the measurements show, there is no great difference in the size of the three skeletons, Vermont, Cornwall and Montreal, which are sufficiently complete to make any comparison worth while. The Cornwall skeleton at Ottawa is rather larger, and the Smith's brickyard one at Montreal rather smaller than the Vermont, but as they are somewhat differently set up, and especially, as the Ottawa specimen alone has anything to take the places of the intervertebral cartilages, exact comparison is not possible.

From comparison of separate bones it seems to the author most probable that the Vermont specimen and the most perfect one in the Redpath Museum are identical, and are sufficiently different from the modern *D. leucas* to warrant placing them as at least a distinct variety, if not species. Had not a species been already established by Thompson and long well-known, it might seem best to regard the fossils as belonging to a small variety of *D. leucas* rather than to add a new specific name; but as it is, it seems best to allow Thompson's species *vermontanus* to stand.

The reasons for separating the fossil from the recent forms have already been given.

The Cornwall whale presents greater resemblance to the modern species than either of the others, and I agree fully with those who have considered it identical. If only we had the ear bones, it would probably be possible to speak with more certain conviction as to the above. As it is, the author would state what has been said rather as his opinion than as an indisputable fact.

As to the Mile-end specimen, since there are only vertebræ, it is impossible to do more than suggest the probability that the individual from which they came was of the same kind as the Montreal and Vermont specimens.

Of the smaller portions of skeletons enumerated, I should not wish to express even an opinion, except that they are all of the genus *Delphinapterus.*

Setting aside those specimens which are too incomplete to make any identification possible, we have in accordance with the foregoing, the following species of fossil cetacea:—

(1) *Delphinapterus leucas,* Gray. Museum of Canadian Geological Survey, Ottawa.

(2) *Delphinapterus vermontanus,* Thompson. Museum of McGill University, Montreal. Vermont State Museum, Montpelier.

(3) *Monodon monoceros,* Linn. Provincial Museum of Nova Scotia, Halifax.

(4) *Megaptera longimana* (*boops*), Gray. Museum of McGill University, Montreal.

LIST OF PLATES.

1. MONODON—(Provincial Museum, Halifax ; from Jacquet River, N. B.) Sternum, one-half natural size. Periotic, natural size.

2. MONODON—(Provincial Museum, Halifax ; from Jacquet River, N. B.) vertebræ, about one-fifth natural size

3. MONODON—(Provincial Museum, Halifax ; from Jacquet River, N. B.) Dorsal vertebræ, one-third natural size.

4. MONODON—(Provincial Museum, Halifax ; from Jacquet River, N. B.) Lumbar and caudal vertebræ, one-third natural size.

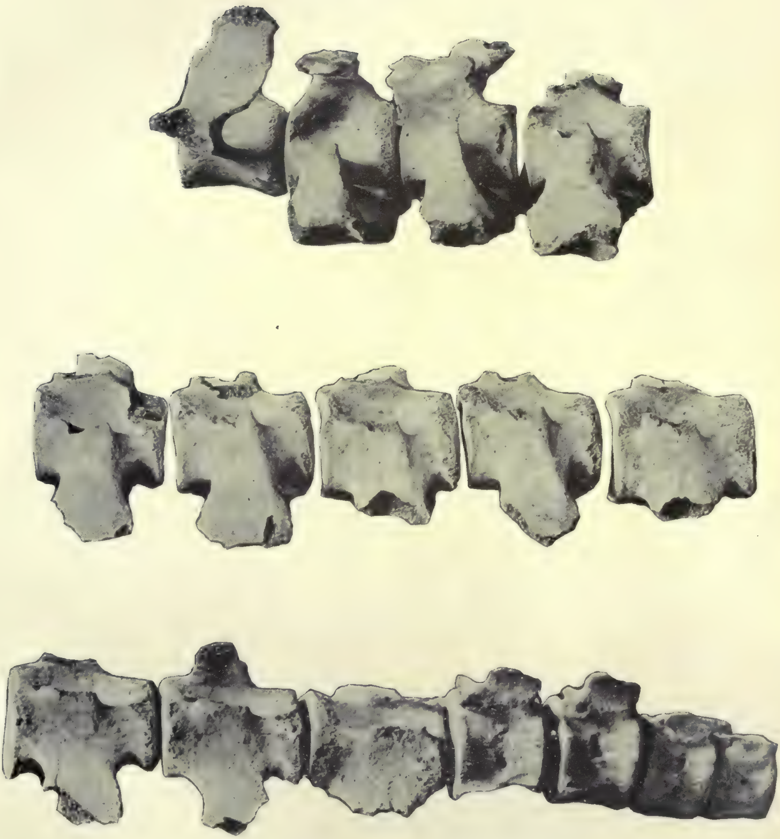
5. DELPHINAPTERUS VERMONTANUS, THOMPSON—(State Museum, Montpelier, Vt. ; from Charlotte, Vt.). Upper figure one-fourteenth natural size ; lower figures about one-fourth natural size.

6. DELPHINAPTERUS VERMONTANUS, THOMPSON—(State Museum, Montpelier, Vt. ; from Charlotte, Vt.). Anterior part of skeleton, about one-seventh natural size.

7. DELPHINAPTERUS VERMONTANUS, THOMPSON—(State Musèum, Montpelier, Vt. ; from Charlotte, Vt.). Sternum and ribs, one-third natural size.

8. DELPHINAPTERUS VERMONTANUS, THOMPSON—(State Museum, Montpelier, Vt.; from Charlotte, Vt.). Periotic, natural size.

MONODON.
(Provincial Museum, Halifax; from Jacquet River, N. B.)
STERNUM, *one-half natural size.* PERIOTIC, *natural size.*

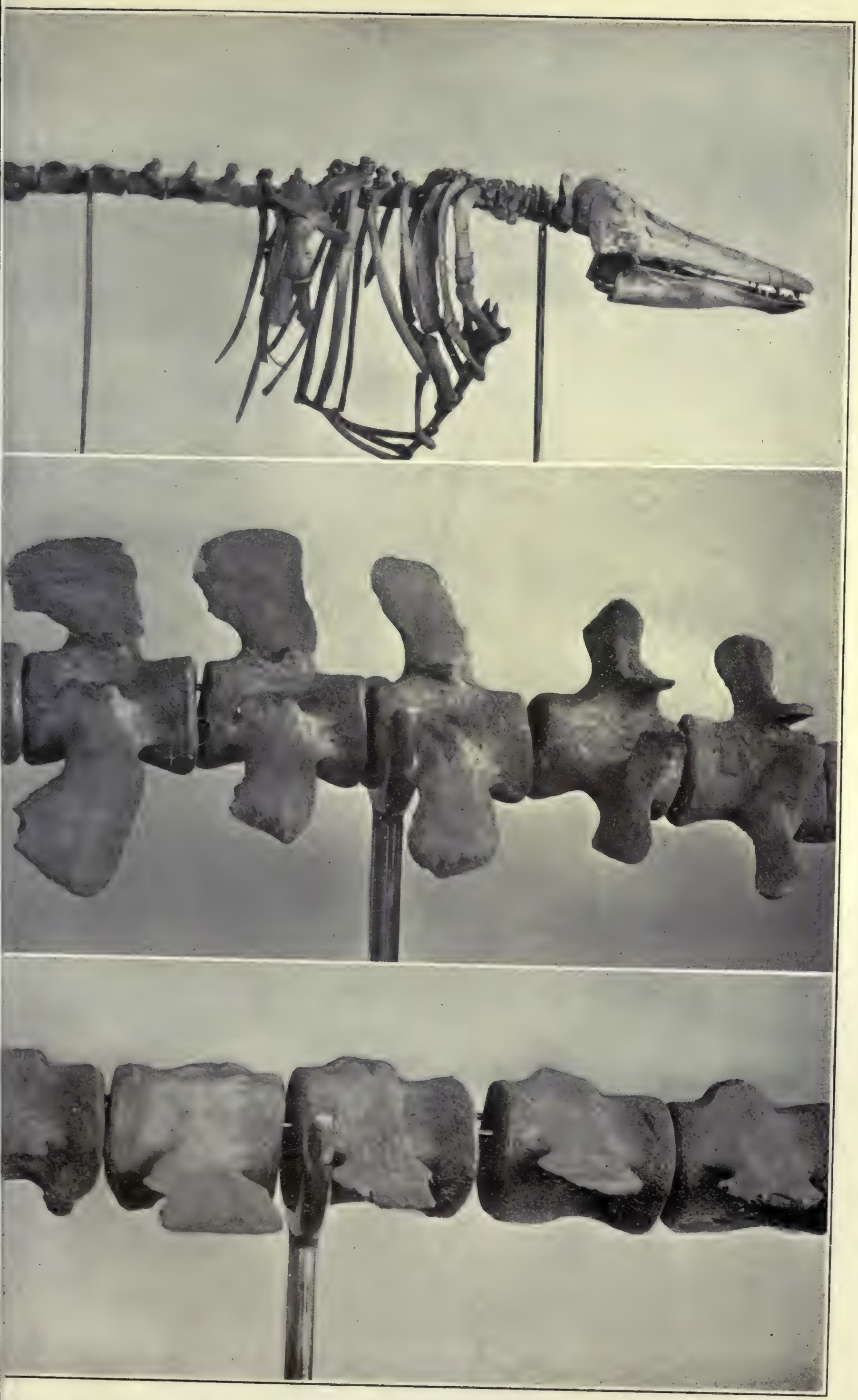


MONODON.
(Provincial Museum, Halifax; from Jacquet River, N. B.)
VERTEBRÆ, *about one-fifth natural size.*

MONODON.
(Provincial Museum, Halifax; from Jacquet River, N. B.)
DORSAL VERTEBRÆ, *one-third natural size.*

MONODON.
(Provincial Museum, Halifax; from Jacquet River, N. B.)
LUMBAR AND CAUDAL VERTEBRÆ, *one-third natural size.*

DELPHINAPTERUS VERN



TANUS, THOMPSON.
; from Charlotte, Vt.)

DELPHINAPTERUS VERMONTANUS, THOMPSON.
(State Museum, Montpelier, Vt.; from Charlotte, Vt.)
ANTERIOR PART OF SKELETON, *about one-seventh natural size.*

DELPHINAPTERUS VERMONTANUS, THOMPSON.
(State Museum, Montpelier, Vt.; from Charlotte, Vt.)
STERNUM AND RIBS, *one-third natural size.*

DELPHINAPTERUS VERMONTANUS, THOMPSON.
(State Museum, Montpelier, Vt.; from Charlotte, Vt.)
PERIOTIC, *natural size*.

THE MYXOMYCETES OF PICTOU COUNTY.—By CLARENCE L. MOORE, M. A., Supervisor of Public Schools in Sydney, Nova Scotia.

(Read 13th April, 1908)

The present paper embodies the results of studies of our Nova Scotia forms of Myxomycetes carried on during the summers of 1905 and 1906. It is here presented as a contribution to our knowledge of the flora of the Province and of the distribution of these organisms which, though generally small and inconspicuous, present in their life histories features of great interest to the biologist. The group is one which has been almost totally ignored by students of our fauna and flora, the only reference to be found to it in any of our local scientific literature being in a paper by the late Dr. Somers on Nova Scotia fungi, published in the transactions of the Nova Scotia Institute of Science. Dr. Somers there lists two of our common forms, viz.: *Lycogala epidendrum* Fr. and *Aethalium septicum* Fr. [*Fuligo ovata* (Schæff) Macbr.]. These two species are also enumerated by Dr. A. H. MacKay in his provisional list of the Nova Scotia fungi, published in the transactions of the same society (Vol. XI, Part I, pp. 122-143).

In the following general discussion of the Myxomycetes, I am necessarily indebted for many facts to the writings of various students of the group, a list of whose works which I have freely consulted will be found at the conclusion of this paper.

Life History. The life history of typical Myxomycetes may be briefly sketched as follows: Under suitable conditions of temperature and moisture the spores germinate, the walls cracking open and the contents escaping in the form of small protoplasmic globules. These soon exhibit amœboid movements,

and, before long, each becomes somewhat elongated or pear-shaped and develops a flagellum, by means of which it is able to move rapidly through the water with a characteristic jerking motion. During this stage the "swarmers," so called, increase rapidly in number by division; but eventually they settle down, the flagella are withdrawn and they again assume the amœboid form, creeping over the substratum. Soon a number of the amœbae coalesce to form a small protoplasmic mass which continues to exhibit amœboid movements as a whole and characteristic internal protoplasmic streamings. The plasmodium, as the protoplasmic mass is now called, increases in size by fusion with other amœbae and by the ingestion and assimilation of food material until the condition of maturity is attained which leads to the fruiting or reproductive phase. The whole plasmodium now becomes heaped up into a number of protuberances into which the whole of its protoplasm passes, with the exception, in some cases, of a small portion which remains behind to form a film-like coating over the substratum and which is known as the hypothallus. When these protuberances are distinct from each other they are known as sporangia, and these may be either sessile or stipitate. The stipe may be prolonged into or through the cavity of the sporangium to form a columella. When the sporangia are vein like or sinuous, retaining largely the characteristic form of the plasmodium, the fructification is described as plasmodiocarpous, or as a plasmodiocarp. In other cases the sporangia are partially fused together, the walls between them may be imperfectly developed and their individuality to a certain extent lost. Such a form of fructification is known as an æthalium and is well exemplified by such a species as *Fuligo ovata*.

The protoplasm of the interior of the sporangia is for the most part converted into spores; but a residual portion frequently gives rise to a capillitium. This may consist of a network of threads or tubules extending throughout the cavity of

the sporangium, with points of attachment to the walls of the latter, or to the columella when present, or to both. The threads or tubules frequently present expansions or thickenings, generally at the nodes of the net, and the expansions may take the form of vesicles filled with granules of the carbonate of lime. In other cases the capillitium consists of simple or branched free threads or elaters exhibiting, as in the Trichias, spiral markings and recalling the elaters of some of the Hepatics.

The spores are small and for the most part spherical. In the different species they vary in size from $3\,\mu$—20μ in diameter, a great many falling between the limits, $7\,\mu$ — 12μ. They are provided with a firm cellulose wall which may be almost smooth but more frequently exhibits thickenings, in the form of spines, warts or reticulating bands. Those of a great many species germinate readily when placed in water at a temperature in the vicinity of 20 degs. C., and cases are recorded where the power of germination has been retained by spores preserved in the herbarium for several years. The time required for germination varies with the species, those of some species germinating in a few hours after being placed in water, while others require several days. My own observations on the germination of spores have been wholly confined to those of *Fuligo ovata*. These I found to germinate readily in ordinary tap water in from four to five hours after immersion. The material used had in every instance been in collection for several months.

The Swarmers. The swarmers, which are developed from the germinating spores, exhibit a hyaline peripheral and granular interior portion. During the flagellate stage they are generally more or less pear shaped, the flagellum projecting from the narrow anterior end. Near this end, also, is found the nucleus and in the broader, posterior part, one or more contractile vacuoles. The posterior border is rendered more or less irregular by pseudopodia which are continually projected and

retracted. Food material is apparently absorbed in solution, but a series of observations recorded by Mr. Arthur Lister (Linn. Journ. Botany, Vol. 25), establishes the fact that, in some instances at least, living bacteria constitute no inconsiderable portion of the food of the swarmers. His observations were made on the swarm cells of *Stemonitis fusca, Trichia fragilis* and *Chondrioderma difforme.* In all these cases, bacteria were seized and drawn into the body of the swarmer by means of pseudopodia projected from the posterior end. The ingested bacteria were stored in vacuoles where they were gradually digested. The process completed, the vacuoles were observed to rise to the surface of the swarmer as bubbles and discharge their contents of refuse and undigested material.

Preparatory to undergoing division the swarm cell withdraws its flagellum and rounds off. The nucleus then divides by karyokinesis, the two daughter cells develop flagella and the swarmer form is resumed.

The swarmers frequently pass into a resting condition, rounding off and developing a thin wall. In this form they are known as microcysts. After being dessicated and remoistened the wall breaks open and the escaping contents resume the swarmer form.

In the fusion of the swarmers to form plasmodia the nuclei do not appear to be involved, but these persist as the nuclei of the plasmodium.

The Plasmodium. The Myxomycetes exhibit two types of plasmodia, the first forming a network of vein-like strands which spreads over the surface of the substratum or within its larger cavities; the second is more watery in consistency and lives in the interstices of decaying wood, from which it issues only for fructification. The first type is characteristic of the Physaraceæ and the plasmodia of various members of this order have furnished most of the material for the investigation of the morphology and physiology of the living plasmodium. This consists

of a hyaline protoplasmic ground substance which, in the periphery, is free from granules, but within is filled with plasmodic grains and frequently grains of carbonate of lime, and shews also numerous vacuoles. The interior is also traversed by a network of channels in which streaming movements are continually going on. The flow in these channels is rythmic, persisting in one direction for a period of from one to two minutes, then reversing and continuing in the opposite direction for a similar period. The streaming, however, continues for a somewhat longer period in the direction of the general movement of the plasmodium. This advances by the ectosarc pushing out in the direction of movement followed by a flow of the interior granular substance. Then follows a short pause, during which the advancing margin withdraws somewhat, but some of the gain made is retained. The next onward movement of the ectosarc carries the border beyond the line previously attained. In this way, by a series of pulsations, a general onward movement of the mass is accomplished.

Numerous nuclei are observable in the substance of the plasmodium, and, as its mass increases, there is a corresponding increase in the number of nuclei by karyokinetic division. The nuclei are undoubtedly those of the original swarmers which coalesced to form the plasmodium, and the product of their division.

In addition to the nuclei, plasmodic granules and refuse or semi-digested material, there are found in the interior of the plasmodia of many species, granules of the carbonate of lime. Associated with the granules, more particularly those of lime, are the pigments which impart to many plasmodia bright and characteristic colors. The plasmodia of *Physarum virescens* and *Fuligo ovata,* for example, exhibit bright shades of yellow, that of *Physarum globuliferum* has a delicate lavender coloring, that of *Lycogala epidendrum* a faint rose. The prevailing color among plasmodia, however, is a watery or opaque white or grey.

A series of careful experiments conducted by Rosanoff (Mem. de la soc. Imp. des. Sc. nat. de Cherbourg, T. XIV) on the plasmodium of *Fuligo ovata* seems to establish that, in this case at least, the plasmodium is strongly negatively geotropic, the general movement of the plasmodium on an inclined surface invariably taking place against the force of gravity. The same investigator observed a like tendency to progress against the centrifugal force when the plasmodium was placed upon a rotating plate.

This negative geotropism is exhibited by many species in connection with the fruiting phase, and appears to be an adaptation to provide for more effectual spore disposal. Preparatory to fruiting, the plasmodic mass will ascend and often almost completely envelop blades of grass, moss plants, etc., and these points of vantage gained the transformation into mature sporangia takes place with astonishing rapidity. Particularly noticeable for this tendency are the plasmodia of *Physarum virescens* and *Physarum cinereum;* but the characteristic is exhibited in a greater or less degree by almost all species.

Plasmodia also shew a marked sensitiveness to temperature changes. That of *Fuligo ovata* is positively thermotropic up to 33 degrees C.—34 degrees C., but becomes negatively so above that point. An exposure to a temperature of 2 degrees C. does not kill this plasmodium, but all movement ceases and a prolonged exposure at that point eventually results in death. The maximum temperature in the case of this species is 52 deg. C.—53 deg. C.

Intense illumination has also been found to check movements of the plasmodium, and in unequal illumination it moves towards the shade; in varying moisture towards the more moist side. The direction and rapidity of movement is also strongly influenced by the presence of appropriate nourishment and, moreover, the plasmodium shews a marked power of discrimination in this connection. A series of very interesting observations

by Mr. Arthur Lister on the plasmodium of *Badhamia utricularis* are reported in the Annals of Botany, Vol. 2, No. 5. He found that the plasmodium of this species could be raised from a sluggish and scarcely moving condition to one of great activity by supplying it with *Agaricus campestris, Boletus flavus* or with the prepared hymenial surface of *Stereum hirsutum.* When *Agaricus fasciularis* was supplied, the plasmodium for three hours refused it altogether, but when at last invaded, in one instance the section was rejected and never touched again and in another the plasmodium which had partaken of this fungus exhibited the most pronounced symptoms of disorder. Mr. Lister also found that starch, after being treated with warm water was readily absorbed and digested by the plasmodium of this species, but that perfectly raw starch remained unaffected.

The process of digestion appears generally to take place in the streaming granular interior substance; but in one instance at least, a like power of digestion was exhibited by the hyaline margin, in which the dissolution of fungus hyphæ was observed to take place.

Resting State. When subjected to a slow drying process, young plasmodia may pass into a resting form, known as macrocysts. The plasmodium breaks up irregularly, each part rounds off and surrounds itself with a wall which becomes thickened and laminated. When placed in water the contents of these cysts swell up and issue forth as amœboid bodies. Macrocysts of this kind occur in *Perichæna* and *Fuligo.*

Another resting form sometimes occurs in fully developed plasmodia. A plasmodium comes to rest and forms a number of lumps of almost horn-like consistency, frequently connected by strands of similar material. These lumps and strands consist wholly of comparatively large cells filled with a granular, generally colored plasma. These forms are designated sclerotia and exhibit the wintering condition of plasmodia. When the sclerotia are brought into contact with water, each cell swells

up and becomes an amœboid body and all fuse together to again form a motile plasmodium.

Sporangia. The structure and peculiarities of the sporangia capillitium and spores, in so far as illustrated by our known Nova Scotia forms, are more or less fully set out in the detailed descriptions of the species in my collection.

In this connection it may be stated that in the evolution of the Myxomycetes, the most prominent feature is the gradual perfecting of the mechanical contrivances to effectuate spore dispersal. The most primitive form of fructification must be regarded as the plasmodiocarp, consisting of a limiting membrane enclosing a mass of spores which only escape by its gradual breaking down. Such forms we find in the less specialized families of the *Cribrariaceæ.*

Starting from this simple form there offshoot two main lines of development exhibiting the gradual perfecting of two distinct forms of adaptation for insuring effectual spore dispersal.

The first consists in the modification of the sporangial wall, its thickenings becoming discontinuous so that the breaking down of the thinner, more delicate areas facilitates the escape of the enclosed spores. This line of development is exhibited through the *Cribrarias* to *Dictydium cancellatium*, where it reaches its higest expression. In this species, the walls of the ripe sporangium become reduced to a mere framework of ribs connected by delicate transverse threads, the whole structure dangling on the end of the stipe which is weak and tenuous at its upper extremity.

The second consists in the development of a capillitium, either with or without a columella. The highest forms with columella are found among the *Stemonitaceæ* in such genera as *Stemonitis, Comatricha* and *Lamproderma.* The most perfect adaptations for securing spore dispersal, however, are found in forms destitute of a columella, such as the *Arcyrias* and *Tri-*

chias; in the former in their highly elastic capillitial nets and in the latter in their free elastic elaters.

The terminal twig in the direct line of development from the primitive plasmodiocarp is, undoubtedly, represented by *Lycogala epidendrum* in which we have a highly specialized æthalium, composed of sporangia destitute of capillitium. The walls of the interwoven sporangia, however, persist to form a pseudo-capillitium of tubules, the lumina of which represent the interstices between the individual sporangia.

Historical and Systematic. The appearance of the Systema Mycologicum of Fries in 1829 marks the first great advance in the systematic study of the Myxomycetes. Previous to this, many species had been recognized, and more or less accurately described, but they were distributed among the various groups of the Fungi—Gasteromycetes, Hymenomycetes, Discomycetes and Mucors. Fries was the first to grasp their essential unity in structure and in development, and accordingly he collected the hitherto scattered genera and species into a distinct group under the name Myxogastres, characterised as " primitus mucilaginosi, fluxiles." That he fully appreciated the marked peculiarities of the vegetative phase of these organisms in comparison with that of other fungi, is clearly shown in his discussion of the group. " Vegetatio," he says, " maxime singularis a reliquorum fungorum prorsus diversa," and in consequence of this knowledge he should, perhaps, have set off the group from the fungi, or at least have given them an independent position in that class. He, however, placed them as a sub-order of the Gasteromycetes, misled by the striking analogies between their mature fructifications, the sporangia, capillitium and spores, and the corresponding structures in that group. The limits of the genera (17) and species according to the form and structure of the fruit bodies were demarked by him with such systematic insight that in great part they still remain.

All of the forms assigned to the Myxogastres by Fries were Myxomycetes producing spores in closed sporangia—the *Endosporeæ* of modern writers. He did not recognize the close relationship to these, of such forms as *Ceratiomyxa*—the modern *Exosporeæ*—and these he assigned to the genus *Ceratium*, of the order *Cephalotrichei*, class *Hyphomycetes*.

In 1833, Link recognizing the fundamental distinction between the Myxogastres and the remaining Gasteromycetes, proposed to erect them into a new order of the class Fungi, under the title Myxomycetes. In the same year this term was also used by Wallroth.

From the time of the publication of the Systema Mycologicum until 1864, little advance was made in a knowledge of the Myxomycetes; but in that year was published the results of deBary's work on the group. It was this investigator who first followed the history of these organisms from the germination of the spore through the swarmer, amœboid and plasmodic phases to fructification and spore formation. Impressed with the remarkable similarity between the life history of these organisms and that of undoubted animal forms, he was constrained to assign them a place without the vegetable, but not necessarily within the animal kingdom. With the Myxomycetes as previously understood, he united the *Acrasieæ* of Van Tieghem, a small group inhabiting the excrement of animals, and proposed for the whole group the term Mycetozoa. Under this head, however, he still retained the term Myxomycetes for the section so named by Link.

The *Acrasieæ* are saprophytes, the plasmodia of which are formed by the aggregation, without fusion, of amœboid bodies. These latter arise directly from the germinating spores and the flagellate stage is wanting. In fructification, these amœboid bodies aggregate in large numbers, creeping up against one another and finally each becomes surrounded by a firm membrane and functions as a spore. In many forms some of the

amœbæ do not give rise to spores, but soon become rigid and united together to form a simple or branched stock. The other amœbæ creeping up on this finally come to rest and form an aggregation of free spores.

The distinction between these organisms and the true Myxomycetes appears to be an essential one, and consists in this—that in the former no true plasmodia are produced, the coalescing amœbæ retaining throughout their individuality.

In 1875, Rostafinski, a pupil of deBary, published a monograph of the group, and, adopting the view of the latter that the life history of the Myxomycetes indicated a wide separation from the fungi, he suppressed that name altogether and adopted instead deBary's Mycetozoa. As this monograph has to a large extent formed the basis of all subsequent systematic work on the group, I insert an outline of Rostafinski's system:

MYCETOZOA.

Division I. EXOSPOREÆ (Ceratium).

Division II. ENDOSPOREÆ.

Sub-division I. AMAUROSPOREÆ. Spores violet or violet brown.

Section A. ATRICHÆ. Fructification without a capillitium. Protodermeæ.

Section B. TRICHOPHORÆ. Fructification always with a capillitium.

Order I. **Calcareæ.** *Cienkowskiaceæ, Physaraceæ, Didymiaceæ, Spumariacea*

Order II. **Amaurochæteæ.** *Stemonitaceæ, Enerthenemaceæ, Amaurochætaceæ, Brefeldiaceæ, Echinosteliaceæ.*

Sub-division II. LAMPROSPOREÆ. Spores variously colored, never violet.

Section A. ATRICHÆ. Fructification without a capillitium.

Order I. **Anemeæ.** *Dictyosteliaceæ, Liceaceæ, Clathroptychiaceæ.*

Order II. **Heterodermeæ.** *Cribrariaceæ.*

Section B. TRICHOPHORÆ. Fructification always with a capillitium.

Order I. **Reticularieæ.** *Reticulariaceæ.*

Order II. **Calonemeæ.** *Trichiaceæ, Arcyriaceæ, Perichænaceæ.*

Zopf in his treatment of these organisms (Die Pilzthiere oder Schleimpilze, 1885), united with them the **Monadineae,** a group mostly aquatic and embracing such forms as *Vampyrella, Bursulla, Pseudospora, Protomyxa,* etc. He also includes in the **Monadineae,** *Plasmodiophora* and *Tetramyxa,* forms which as will be seen, are regarded by most subsequent students as more nearly related to the true Myxomycetes. The second sub-division in Zopf's system is the **Eumycetozoa** with the same limitations as deBary's Mycetozoa.

This scheme of classification is open to criticism for, while it is perhaps not possible to draw a sharp line between the Monadinæ and the true Myxomycetes, it is undoubtedly true that the former appear to be in the direct line of ascent to the rhizopods and heliozoa and hence to the whole series of animal forms. Moreover, while the characteristic plasmodium formation is exhibited in a number of them, for example *Protomyxa,* it is in the great majority unknown.

Schröter (Engler & Prantls Die Nat. Pflanzenfamilien) adopts the term Myxomycetes which he uses synonymously with de Bary's Mycetozoa; but he admits into the group such forms as Plasmodiophora, which were excluded by the latter as doubtful.

He divides the Myxomycetes into three principal groups:

A. Mature fructification consisting of a mass of free spores.

1. Saprophytes—the amœboid bodies uniting in masses but not fusing.

Acrasieae.

2. Parasitic in the interior of living plant cells—so far as known true plasmodia.

Phytomyxinae.

B. Spores produced in the interior of sporangia, or on the outside of discoid or columnar fructifications.

Myxogasteres.

Massee in his monograph (1892) uses the Friesian term,

Myxogastres with the limits originally assigned it—that is, as co-extensive with the *Endosporeæ* of Rostafinski's classification and narrower than the *Myxogasteres* of Schroter which is a synonym of Rostafinski's *Mycetozoa.*

Lister, on the other hand, accepts the group *Mycetozoa* as established by Rostafinski, but excludes *Dictyostelium,* one of the *Acrasieæ,* which had been admitted by the latter evidently through a misapprehension of the nature of its plasmodium. "We have thus," he says, "a clearly defined group of organisms separated from all others by the following combination of characters. A spore provided with a spore wall produces on germination an amœboid swarm cell which soon acquires a flagellum. The swarm cells multiply by division and subsequently coalesce to form a plasmodium which exhibits a rythmic streaming. The plasmodium gives rise to fruits which consist of supporting structures and spores. In the *Endosporeæ* these have the form of sporangia each having a wall within which the free spores are developed. A capillitium or system of threads, forming a scaffolding among the spores is present in most genera. In the *Exosporeæ* the fruits consist of sporophores bearing numerous spores on their surface." (A monograph of the Mycetozoa, p. 2.)

Macbride in his North American Slime Moulds (1899), uses the term "Myomycetes (Link) de Bary," as a general title, but includes in the group such forms as Plasmodiophora which, as has been said, were excluded by de Bary in his treatment of the group as being of doubtful affinity. As thus limited, the group embraces the Phytomyxinæ and Myxogasteres of Schroeter's system.

Macbride groups the Myxomycetes as thus defined into three main divisions or sub-classes:

A. Parasitic in the cells of living plants.

Sub-class. **Phytomyxinae.**

B. Saprophytic, developed in connection with decaying vegetable material.

(*a*) With free spores.

Sub-class. **Exosporeae.**

(*b*) With spores in receptacles or sporangia.

Sub-class. **Myxogastres.**

The correctness, however, of including in the group such forms as *Plasmodiophora* may well be questioned. It still remains unsettled as to whether these form true plasmodia, the production of which must be taken as the great outstanding feature in the life history of the remaining members of the class. This doubt might well be considered sufficient ground for their exclusion.

In the account of Nova Scotia forms which follows, I have, however, adopted the classification and nomenclature of Macbride *in toto*. The description of species have been compiled from collections of my own made during the summers 1905 and 1906 in the vicinity of Pictou town and in various other parts of Pictou county. The list of forms is undoubtedly far from exhaustive, but I think will be found to include most of our common Nova Scotia species and some which will probably be found to be of rather rare occurrence.

One form I have described as a new species. I may say that a portion of the gathering from which the description is compiled was submitted to Dr. Macbride, who reported it tentatively as *Margarita metallica* Lister, a species hitherto unknown from this continent. A careful comparison with the description of *Margarita metallica* as given by Lister has led me to the conclusion that we have here a distinct species of the genus *Margarita.*

In determining spore characteristics a Leitz 1/12 oil immersion objective was used in combination with a No. 5 eyepiece affording a magnification of 1200 diameters. Except where otherwise indicated, the drawings are camera lucida sketches made during my studies of the various species.

In the foregoing account of the group I have refrained from discussing the vexed question as to whether these organisms should be assigned to the animal or to the vegetable kingdom; whether they belong to the province of the zoologist or the botanist. This question does not appear to me to be one of very great moment. All students agree that the group is a terminal one and distinct from the main line of development of plants and of animals alike. "The most characteristic morphological peculiarity of the plants," says Huxley, "is the investment of each of its component cells by a sac, the walls of which contain cellulose or some closely analogous compound; and the most characteristic physiological peculiarity of the plant is its power of manufacturing protein from chemical compounds of a less complex nature."

"The most characteristic morphological peculiarity of the animal is the absence of such cellulose investment. The most characteristic physiological peculiarity is the want of power to manufacture protein out of simpler compounds."

Applying the foregoing as criteria it is clear that the Myxomycetes in their vegetative phase shew undoubted affinities with the lower animal forms while in their fruiting phase plant characteristics predominate.

The view as to their true position in the world of organized things which seems to commend itself most is that formulated by Shröter. "At the same point where the Schizomycetous series takes rise, there began certain other lines of development among the most primitive protoplasmic masses. Through the amœba one of these lines gave rise on the one hand to Rhizopods and Sponges in the animal kingdom; on the other hand to the Myxomycetes among the fungi."

MYXOMYCETES (Link) de Bary.

Organisms destitute of chlorophyll of which the vegetative phase consists of a naked mass of protoplasm. Reproduction takes place by means of spores which are produced either (1)

free or (2) externally on columnar or membranous sporophores or (3) in closed capsules or sporangia. In germinating the spores produce amœboid bodies which pass through a ciliated stage and which eventually fuse to form a multinuclear protoplasmic mass, the plasmodium, which gives rise to the fructifications.

Sub-class 1. PHYTOMYXINÆ.—Mature fruit bodies converted into an aggregation of free spores. Parasitic in cells of living plants.

Sub-class 2. EXOSPOREÆ.—Spores formed superficially on membranous or columnar sporophores. Saprophytic.

Sub-class 3. MYXOGASTRES.—Spores formed within sporangia. Saprophytic.

PHYTOMYXINÆ Schröter.

Parasitic in the cells of living plants. The spores are formed by the simultaneous division of the mature plasmodium and lie free in the cells of the host.

Genus, **Plasmodiophora** Woronin.

The only representation of the genus and sub-class which has come under my observation is:

1. *Plasmodiophora brassicæ* Woronin.—This species is parasitic on various cruciferæ such as the turnip, cabbage, rape and kale, producing in these plants the disease popularly known as "Club root." The roots of infected plants exhibit irregular and distorted growth, become covered with irregular protuberances and swellings and eventually decay. A section through one of these swellings shews the enlarged parenchymatous cells almost completely filled either with plasmodium (?) of the parasite or with the spores. These are spherical and about 1.5μ in diameter.

What is probably the same parasite also occurs here on species of wild mustard and is pretty generally distributed through-

out the county, although only in a few districts does it appear to occasion serious damage to crops. From one district, however, namely, that of Lower Mount Thom, the loss is reported as amounting to 25 per cent. of the total turnip crop of the present year (1906).

EXOSPOREÆ Rost.

Genus, **Ceratiomyxa** Schröter.

Ripe fruit bodies consist of membranous processes which may be columnar and in tufts or may form a net-work. The surface of these processes or sporophores is divided into a great number of polygonal areas, obscurely indicated in the mature fruit, from the center of each of which arises a delicate stalk supporting a single spore.

The phenomena exhibited in Ceratiomyxa in connection with spore germination and the development of the swarm cells differ markedly from those presented in this connection by members of the Endosporeæ. The mature spores germinate very readily in water, the contents escaping in the form of an ellipsoid mass of protoplasm which remains quiescent for some hours. Amœboid movements may then be observed and by successive constrictions the original spore mass becomes divided into eight small spherules which continue connected together until each develops a flagellum. By the lashing of these the associated group may swim about for some time but eventually the individuals break apart and their subsquent development resembles in all respects that observed in the *Endosporeæ*.

2 *Ceratiomyxa fructiculosa* (Muell.) Macbr.—Fructification white, forming mould like patches on decaying wood in shaded situations. The sporophores are columnar, white; the spores colorless by transmitted light, large, elliptical or ovoid. They measure 6—8 μ x 10—14 μ and the delicate stalks on which they are supported average 15 μ in length.

Found on decaying pine logs.

3. *Ceratiomyxa porioides* (Alb. & Schw.) Schröter.—In this species the plate-like sporophores are connected together after the manner of a honeycomb, giving the fructification the appearance of a small, sessile, upturned polyporus. The plasmodium is watery white and after emerging for fructification forms a mucilaginous porose layer extending over a considerable area. The spores are similar to those of the preceding species.

Found on decaying hemlock blocks

Lister in his monograph of the Mycetozoa includes both of the foregoing species in *Ceratiomyxa mucida* Schröter.

Myxogastres (Fries) Macbr.

Myxomycetes in which the spores are developed in sporangia. The germinating spores produce amœboid swarmers which eventually lose their flagella and become amœboid bodies. They multiply by division and, later, fuse to form plasmodia. In the mature condition fruit bodies are formed consisting chiefly of spores enclosed in a structureless limiting membrane, the peridium, which may consist of one or two layers. In most cases the sporangia contain in addition to the spores a structure consisting of filaments or tubules, of characteristic form, the capillitium.

Order I.

PHYSARACEÆ.

Capillitium present, generally containing lime deposits in the form of amorphous granules which are aggregated in vesicular expansions of the capillitial threads forming the so-called lime knots. Lime granules also occur in connection with the peridium and stipe.

In the family Physareæ the lime deposits occur both in the peridium and in the capillitium which is intricate. In the family Didymieæ the capillitium is comparatively simple and the lime deposits are confined to the peridium.

Family, PHYSAREÆ.

This family is represented in my collection by seven species distributed through four genera, viz.: *Fuligo, Physarum, Tilmadoche* and *Leocarpus.*

Genus, **Fuligo** (Haller) Pers.

In this genus the sporangia are elongated and interwoven to form a thick cake-like fruit body or æthalium in which it is impossible to trace the individual sporangia. The outer portion of the æthalium forms a hard calcareous crust and the whole rests upon a well developed hypothallus. The capillitium is well developed, consisting of a filamentous net with irregular lime vesicles.

4. *Fuligo ovata* (Schæff) Macbr.—Æthalia pulvinate resting on a well developed spongiose hypothallus; frequently covering an area of several square centimetres and in some cases attaining a height of two centimetres. The outer calcareous crust varies much in the extent to which it is developed, in some instances, being thick and firm, in others, scarcely evident. The crust also varies in color from white to orange. The capillitium consists of a net of hyaline filamentous tubules flattened at the angles. The lime knots are irregular in shape and in some gatherings almost wanting. Spores violet colored by transmitted light, smooth, 7—10 μ in diameter.

This is a common species with us occurring everywhere on moss, rotten wood, etc.

Genus, **Physarum** (Persoon) Rost.

In this genus the capillitium consists of irregularly branching filamentous tubules united to form a net with vesicular expansions, generally at the nodes, containing amorphous lime granules. The ends of the capillitial filaments are attached to the peridium which at maturity ruptures irregularly.

In all the species which I have collected the fructification consists of distinct sporangia.

5. *Physarum virescens* Ditmar.—Plasmodium lemon color. Sporangia clustered in heaps, greenish yellow in color, sessile or very short stipitate. The aggregate habit gives rise to considerable irregularity and frequently sporangia fuse together. When regular they are obovoid or spherical in shape and about $.2^{mm}$ broad. The yellow color of the peridium is due to small lime granules. Capillitium rather scanty, the hyaline threads delicate, the lime knots fusiform or irregular in shape, yellow or orange yellow in color. Spores violet brown by transmitted light, delicately warted, 7—9.5 μ in diameter.

On moss.

6. *Physarum cinereum* (Batsch) Pers.—Sporangia small, about one-third of a millimetre in diameter, sessile, closely crowded and superimposed covering considerable areas. They are frequently irregular and contorted. The peridium is membranous, grey in color from numerous included lime granules; in old fructifications, when many of the sporangia have split open, this color may be concealed by the purple brown of the spores in mass. Capillitium dense with irregular, angular and branching white lime knots which are frequently confluent. The hyaline threads are short. Spores violet brown by transmitted light almost smooth, 10—11.5 μ in diameter.

Found fruiting on moss and blades of grass, sometimes completely covering these with its heaped sporangia; also on decaying wood.

7. *Physarum globuliferum* (Bull.) Pers.—Plasmodium pale lavender in color. Sporangia stipitate, erect, spherical, about $.45^{mm}$ in diameter, white from encrusting lime granules. Stipe white, brittle, tapering upward about $.9^{mm}$ in length. Columella not evident. Capillitium abundant and delicate, the lime knots small, white. Spores violet tinted by transmitted light, almost smooth, 8μ in diameter. They show in this species a tendency to adhere in clusters.

On decaying *Abies balsamea*. Not common.

Genus, **Tilmadoche** (Fries) Rost.

In this genus the capillitial filaments regularly branch dichotomously, anastomose sparingly and terminate in delicate free ends. The lime knots are small and fusiform. In all the species the sporangia are distinct.

8. *Tilmadoche alba* (Bull) Macbr.—Sporangia grey or white, spherical, stipitate, nodding, about $.4^{mm}$ in diameter. Peridium with crowded clusters of included white lime granules. Stipe short and stout, about equal to the diameter of the sporangium or slightly exceeding it, subulate, dark in color below, pale towards the upper part. The capillitial threads arise from the base of the sporangium, branch dichotomously with flattened expansions at the axils, and are provided with numerous small, white lime knots. Spores violet tinted by transmitted light, smooth, about 8μ in diameter.

On decaying conifers, fairly common.

9. *Tilmadoche viridis* (Bull) Saccardo.—Sporangia scattered, yellow or orange in color with a cast of green, stipitate, spherical, nodding. Peridium with numerous included lime granules. Stipe about 1^{mm} long, tapering upward, furrowed, twisted at the top; dark below from refuse material becoming pale above. Sporangia about $.5^{mm}$ in diameter. Capillitium abundant persisting as a tuft after the dispersal of the spores. Lime knots orange colored and fusiform, generally small. The capillitial threads are delicate, branch frequently and are not expanded at the axils. Spores violet colored by transmitted light, nearly smooth, 9—10μ in diameter.

On decaying *Fagus ferruginea.*

Genus, **Leocarpus** (Link) Rost.

Peridium double, the outer thick, calcareous, brittle and shining. Capillitium consists partly of hyaline threads and partly of broad anastomosing tubules filled with colored lime granules.

10. *Leocarpus fragilis* (Dickson) Rost.—Sporangia obovoid, 1.8^{mm} long, $.9^{mm}$ broad, shining, brown in color. Peridium double, stipe very weak, straw colored, not supporting the sporangia which generally lie on the substratum anchored by the weak, thread-like stipes. Capillitium forming a net the terminal branches united with the inner peridium. The net consists partly of hyaline tubules somewhat expanded at the nodes and partly of broader, more expanded tubules packed with dark colored lime granules. Spores violet colored by transmitted light, spinulose, 12—14μ in diameter.

On decaying *Abies balsamea*, moss, leaves, etc.

In all of my collections the sporangia are numerous and crowded.

Family, DIDYMIEÆ.

Characterized among the Physaraceæ by the calcareous deposits being confined to the peridium. The family is represented in my collections by but two species, the first of which appears to be one of our commonest Myxomycetes.

Genus, **Didymium** (Schrad) Fr.

Fruit bodies separate sporangia or plasmodiocarps. Peridium simple or double, the outer wall covered more or less completely with lime crystals which generally lie loosely upon it or more rarely are united into a firm crust. Columella wanting or present and hemispherical or disc shaped. Capillitium filamentous, free from lime.

11. *Didymium melanospermum* (Pers.) Macbr.—Sporangia gregarious covering areas of several square centimetres in extent; light ashen grey or almost white in color; depressed hemispherical deeply umbilicate below, stipulate, about $.75^{mm}$ in diameter. Columella hemispherical. Stipe black, short, stout below tapering upward, one-sixth of a millimetre or less in height, the sporangia in fact sometimes apparently sessile. Peridium thickly frosted with stellate lime crystals. Hypothal-

lus evident. Capillitium consisting of delicate flexuous threads sparingly branched extending from the columella to the peridium to which the ends are attached. Spores large, purplish brown by transmitted light, distinctly warted, 10—12 μ in diameter.

One of our most common species occurring on decaying wood and bark of various trees—more commonly those of deciduous species.

12. *Didymium minus* Lister.—This species differs from the last in its smaller sporangia, .5—.6^{mm} in diameter, its relatively longer and more slender stipe imparting a more trim and erect appearance. The spores also are smaller, 9.5—10 μ in diameter, delicately roughened.

On fallen leaves of *Fagus ferruginea.*

Lister regards this as merely a well marked variety of *Didymium farinaceum* Schrader, of which *Didymium melanosperum* (Schæff.) Macbr. is a synonym.

Order II.
STEMONITACEÆ.

Capillitium present, formed of solid strands, plate or filaments. Columella usually well developed and from this the capillitium arises and by repeated branching and anastomosing forms a more or less complicated network. Spores in mass dark violet or more rarely brown.

Family, STEMONITEÆ.

Fructification when mature generally consisting of distinct sporangia. Peridium delicate soon disappearing, destitute of lime. Capillitium usually arising from a columella, formed of solid filaments without lime.

This family is represented in my collection by six species and two genera.

Genus, **Stemonitis** (Gleditsch) Rost.

Sporangia standing close together, before maturity forming a slimy mass which only later divides into the individual sporangia. A columella is present and from this the capillitial filaments branch out on all sides and, repeatedly dividing and anastomosing with one another, form at the periphery a characteristic more or less close meshed net. Peridium evanescent.

13. *Stemonitis fusca* (Roth.) Rost.—Sporangia cylindrical growing in tufts on a well developed hypothallus, purplish black in color, becoming pallid after spore dispersal. Total height about 5^{mm}. Stipe black, about one-third the total height. Columella becoming sinuous some distance below the summit of the sporangium, but traceable almost to the apex. The capillitial branches arise from the columella at right angles and anastomosing form an open interior scaffolding of dark drown threads with flat expansions at the junctions. The peripheral net formed by the anastomosing of the ultimate capillitial branches shews polygonal meshes varying considerably in size. Peridial processes conspicuous. Spores pale violet by transmitted light, smooth, 7—8 μ in diameter.

On decaying *Pinus strobus* and other conifers.

14. *Stemonitis maxima* Schweinitz.—Sporangia in tufts, cylindrical, stipitate, purple black in color becoming grey with a purple tint after spore dispersal. Total weight about 15^{mm}. Stipe black, about one-half the total height. Hypothallus thin, transparent and shining. Columella dissipated near the apex in capillitial branches. The peripheral net of uniform, small meshes, the peridial processes short. Interior scaffolding open. Spores violaceous grey by transmitted light, regularly and beautifully reticulated, 7—8 μ in diameter.

On decaying *Fagus ferruginea.*

15. *Stemonitis smithii,* Macbr.—Sporangia forming dense clusters on a well developed hypothallus, cylindrical, stipitate.

Total height about 12^{mm}. Stipe black, about one-third the total height. Columella dissolving in capillitial branches some distance below the apex. The interior scaffolding is made up of strong, brown, generally uniformly thickened threads which do not shew the same tendency to form flat expansions such as are exhibited in the two preceding species. Spores almost colorless by transmitted light, smooth, 6—7 μ in diameter.

Common in coniferous woods.

Genus, **Comatricha** (Preuss) Rost.

Sporangia isolated, cylindrical, ovoid or spherical, stipitate. Stipe continued up into the columella and giving off branches which anastomose more or less freely to form the capillitium, the ultimate tips free. Peripheral net generally wanting but in some cases imperfectly developed.

16. *Comatricha nigra* (Pers) Schröter.—Sporangia scattered, erect, ovoid, stipitate. Stipe relatively long, slender and tapering upward, about 2^{mm} in length. Expanded capillitium $.3^{mm}$ x $.6^{mm}$. Peridium evanescent. Hypothallus none. Columella extending to about the middle of the sporangium where it dissolves in capillitial branches. Capillitium consisting of a tangled net of dark brown, stiff, uniformly thickened threads which arise from all parts of the columella, branching and anastomosing to form the net. Free ends and short peridial processes are numerous at the periphery. Spores violaceous brown by transmitted light, smooth or nearly so, 7—9 μ in diameter.

A very neat, trim looking little species found on decaying *Abies balsamea* and other conifers.

17. *Comatricha stemonitis* (Scop.) Sheldon.—Sporangia gregarious, cylindrical, stipitate. Total height, 3—4^{mm}. Stipe black and shining one-fourth to one-third the total height. Hypothallus distinct. Columella reaching nearly to the summit of the sporangium, becoming weak and flexuous in its upper

parts, or, in some cases, terminating abruptly at the apex of the sporangium in an enlarged extremity which gives rise to a number of branches. Interior scaffolding of the capillitium dense, of stout purplish brown threads. Peripheral net stemonitis-like but discontinuous and generally more fully developed towards the base of the sporangium. Free ends common, often bifurcated. Spores violaceous grey by transmitted light, marked with a few scattered, umbo-like warts, the areas between these roughened, warted, or reticulated, 6—7.5μ in diameter.

On decaying conifers.

This appears to be a very variable species. The only constant spore character is the presence of the umbo-like warts. I have specimens in which the surface between these is beautifully reticulated, others in which it is roughened, and still others where it is minutely warted. The extent to which a peripheral net is developed is also subject to great variation.

Family, LAMPRODERMEÆ.

This family is characterized by the capillitium being developed chiefly or solely from the summit of the columella. It is represented in my collections by but one species of the genus Lamproderma.

Genus, **Lamproderma** Rost.

Sporangia distinct, stipitate. Stipe black. Capillitium consisting of branched anastomosing threads radiating from the upper part of the columella. The peridium is shining, iridescent and somewhat persistent, particularly at the base of the sporangium.

18. *Lamproderma arcyrionema* Rost.—Sporangia distinct, gregarious, stipitate. Total height 1^{mm} or slightly exceeding this. Stipe relatively long, tapering upward about $.6^{mm}$ in length. Diameter of expanded capillitium about $.5^{mm}$. Peridium falling away except at the base where it persists as a collar. Columella reaching to about the middle of the spor-

angium where it divides into the primary branches of the capillitium. These repeatedly divide and anastomose to form a crisped net of purple brown threads. Free ends short. Spores pale purplish grey by transmitted light, nearly smooth, 6—7 μ in diameter.

On decaying *Abies balsamea,* not rare.

Order III.

CRIBRARIACEÆ.

This order is characterized by the entire absence of a capillitium and by the color of the spores which are either pallid or some shade of brown without any violet tint. In the less highly developed forms the fructifications are plasmodiocarpous or æthaloid; in the higher forms they consist of distinct sporangia. In these, too, the peridium becomes locally thickened and at maturity the unthickened portions break away, leaving the modified portions in the form of a closed net of flat bands or plates.

Family, LICEÆ.

Fructification plasmodiocarpous.

The family is represented in my collections by a single species.

Genus, **Licea** (Schrader) Rost.

The generic characteristics are well exemplified by—

19. *Licea variabillis* Schrader.—Fructification plasmodiocarpous, irregular, annulate, repent, varying greatly in size, dark red brown in color. The peridium is double, the outer opaque, filled with particles of refuse matter; the inner smooth, delicate, translucent. Spores pale yellowish by transmitted light, large, strongly spinulose, 13—14μ in diameter.

On decaying *Pinus strobus,* not common.

Family, TUBIFEREÆ.

Fructification æthaloid, the sporangia tubular, seated on a well developed hypothallus, closely appressed, numerous and in

one or more series; typically rupturing irregularly at the apex. This family is represented in my collections by two species.

Genus, **Linbladia** Fries.

Sporangia compacted on a spongy hypothallus in one or more series, short, tubular. When in a single series sometimes distinct and short stipitate. Peridium containing numerous dark granules. Spores olivaceous.

20. *Linbladia effusa* (Ehr.) Rost.—Sporangia compacted in a thick spongy hypothallus in a single series (in all of my collections), tubular, about 1^{mm} high and .5—$.75^{mm}$ in diameter, almost black. Walls of the sporangia membranous with numerous small, round, dark granules. Fructifications frequently covering considerable areas, as large as 20 x 15^{cm}. Spores almost colorless by transmitted light, smooth, 6.5—7μ in diameter.

On decaying logs and on leaf mould in coniferous woods. Common.

Genus, **Tubifera** Gmelin.

Fructification æthaloid formed of closely appressed cylindrical sporangia seated on a well developed hypothallus. The side walls are grown together but the individual sporangia are nevertheless, clearly discernible. Sporangia rupturing at the apex.

21. *Tubifera ferruginosa* (Batsch Macbr.—Sporangia long, tubular, cylindrical or prismatic from mutual pressure, convex above, appressed together to form a pulvinate æthalium, sessile on a well developed hypothallus. Walls of the sporangia membranous. Spore mass umber brown. The æthalia may cover an area of several square centimetres. The individual sporangia are from 2^{mm} to 4^{mm} in height and about $.5^{mm}$ in diameter. Spores almost colorless by transmitted light, delicately reticulated over the greater portion of their surface, 6.5—7μ in diameter.

On decaying *Psuga canadensis* and other conifers. Common.

Family, CRIBRARIEÆ.

Fructifications of distinct sporangia. The peridium becomes locally thickened and at maturity the unmodified parts fall away, leaving the thickened portions in the form of a closed net of flat bands or plates. The plasmodia live in decaying wood and issue from this for fructification in the form of small, slimy lumps, each of which gives rise to a sporangium.

The family is represented in my collections by four species, three of which belong to the genus Cribraria and one to the genus Dictydium.

Genus, **Cribraria** (Pers) Schrader.

Sporangia distinct, stipitate. The thickenings of the peridium take the form of a delicate persistent net of band-like filaments with thickenings at the nodes. The lower part of the peridium generally persists in toto to form the so-called calyculus, strengthened by radiating ribs marked by dark plasmodic granules.

22. *Cribraria argillacea* Persoon.—Sporangia umber brown, crowded, spherical, stipitate, about .5^{mm} in diameter. Stipe brown, stout, short, about .3^{mm} long. Peridium persistent and in the lower part marked by thickenings in the form of broad, dark brown, radiating bands with numerous plasmodic granules; above this the bands become narrower and anastomose, but do not present thickenings at the nodes; on the top of the sporangia there is observable, here and there, a tendency to form thickenings at the nodes, and the net becomes more typically cribraria like. Spores light brown in mass, pale by transmitted light, distinctly warted, about 6.5μ in diameter.

On decaying *Abies balsamea*. Rare. The largest fructification which I have seen covers an area 5 x 5^{mm}.

23. *Cribraria macrocarpa* Schrader.—Sporangia gregarious, spherical, stipitate, nodding, umber brown or yellowish brown in color, about .7^{mm} in diameter. Stipe about 1.5^{mm} long, .08^{mm}

in diameter, at the base, tapering upward. Calyculus with radiating ribs, the margin toothed, the teeth merging into the net above. The nodes are flattened, elongated and confluent near the calyculus; in the upper parts, prominent, polygonal and angular, the angles continued into the connecting threads. These latter are delicate and free ends are common. The meshes of the net are 3—5sided. Spores almost colorless by transmitted light, slightly roughened. 5—6μ in diameter.

This is with us a rather common species forming large fructifications on decaying *Psuga canadensis* and other conifers. The largest fructification which I have met with was 30 x 10^{cm}.

24. *Cribraria dictydioides* Cke and Balf.—Sporangia gregarious, spherical, small, $.5^{mm}$ in diameter, cernuous. Stipe 1^{mm} long, dark. Calyculus well developed marked with radiating lines of dark plasmodic granules, the margin denticulate. The nodes of the net are dark brown, connected by rather broad hyaline threads radiating from the angles. Free ends numercus. In the lower part of the net the nodes are more elongated and branching. Spores almost colorless by transmitted light, faintly warted, 7—8μ in diameter.

On decaying conifers of various species. Not rare.

Genus, **Dictydium** (Schrad.) Rost.

Sporangia distinct. Peridium with narrow band-like thickenings on the inner surface, radiating from the attachment of the stipe to the top of the sporangium and connected by delicate transverse thickenings. In the mature condition, the unthickened portions disappear and the thickenings persist as a basket-like structure with rectangular meshes, enclosing the spore mass.

25. *Dictydium cancellatum* (Batsch.) Macbr.—Sporangia closely gregarious, depressed globose, cernuous. The older sporangia become umbilicate at the top; $.5^{mm}$ in diameter or slightly larger. Stipe .6—2.4^{mm} in length, tapering upward, at the top weak, twisted and white. Calyculus generally wanting.

Spores brown or purplish in mass, reddish by transmitted light, smooth, 6.5—7.5 μ in diameter.

This is undoubtedly our most common Myxomycete occurring on decaying wood of a variety of deciduous and coniferous trees, but much more frequently of the latter.

Order IV.

LYCOGALACEÆ.

Sporangia fused together to form an æthalium with a tough membranous outer covering. Capillitium consisting of branched smooth or wrinkled tubules. The order contains but a single genus, represented in my collections by one species.

Genus, **Lycogala** Micheli.

Æthalia conical or depressed globose, with an outer covering consisting of two sharply defined layers; the outer containing vesicles filled with air and traversed by flattened tubes which are continuous with the tubes of the capillitium. Capillitium a system of branching tubules arising as above stated and with numerous free, rounded ends.

26. *Lycogala epidendrum* (Buxb.) Fries.—Æthalia depressed globose, most commonly appearing in clusters on decaying wood; they often vary in size in the same cluster from 3^{mm} to 1^{cm} in diameter. Color pinkish grey. Cortex papery, the spores escaping by an irregular rupture at the apex. Capillitium consisting of numerous branched tubules with wrinkled and roughened walls and numerous rounded free ends. Spore mass pinkish grey. Spores almost colorless by transmitted light, their surfaces roughened in ridges, which on some parts take the form of an irregular reticulation 6—7 μ in diameter.

This is the most puffball-like of the Myxomycetes. It is very common on decaying conifers from which the plasmodium issues in the form of rosy globular masses of protoplasm. With us it is the first to appear in the spring, beginning to fruit about the first of June.

Order V.

MARGARITACEÆ.

This order is thus characterized by Lister: "Sporangia normally sessile, sporangium wall single, smooth, translucent; capillitium abundant, not consisting of separate elaters nor combined into a net; spores pinkish or yellowish grey."

Genus, **Margarita** Lister.

"Sporangia globose; capillitium a profuse web of coiled hair-like, sparingly branched, slender, solid threads with indistinct attachments to the sporangium wall."

27. *Margarita pictoviana* Sp. Nov.—Sporangia small, depressed globose, sessile, clustered, at times confluent and irregular in form, brown in color with a metallic lustre when fresh, .5—1^{m} in diameter when regular. Peridium single, smooth translucent pale yellowish by transmitted light with scattered included concolorous granules. Capillitium not copious, of delicate somewhat flattened hair-like threads papillose along both margins, the flattened surface roughened, rarely branching and occasionally shewing attachments to the peridium; threads about 2μ in maximum diameter. Spores pale yellowish by transmitted light, spinulose 11—13.5μ in diameter. Spore mass pinkish grey. Collected on decorticated decaying *Psuga canadensis* at Pictou, N. S., September 23rd, 1905.

Order VI.

TRICHIACEÆ.

Fructifications of distinct sporangia, rarely plasmodiocarpous. Capillitium consisting of definite threads, free or attached to the sporangial wall or united to form an elastic net. Generally marked with thickenings in the forms of warts, spines, spirals, rings, cogs, etc.

Family, ARCYIEÆ.

Characterized by the capillitium forming a distinct elastic net attached below to the sporangial wall. The thickenings on the threads take the form of spines, warts, cogs, half ring, etc., often arranged in a spiral but never take the form of continuous spiral bands. The family is represented in my collections by four species all of the genus *Arcyria.*

Genus, **Arcyria** (Hill) Pers.

Fructifications of distinct stipitate sporangia; the peridium evanescent above, persistent below as a calyculus. Capillitium a more or less elastic net without free ends, attached below to the interior of the stipe or to the calyculus. The threads or tubules are marked with spines, cogs, half rings, etc. The stipe is hollow and filled with spore-like cells or vesicles.

28. *Arcyria nutans* (Bull.) Grev.—Sporangia cylindrical, distinct, stipitate crowded on a well developed hypothallus, dusky yellow in color and about 7^{mm} in total height. Stipe generally long, 5^{mm} in length, and weak, filled with spore-like vesicles. Capillitium expanding to form a very loose, drooping net, dusky yellow in color, one-half to three-fourth of a centimetre in length, loosely attached to the calyculus, the tubules are marked with close-set spines and cogs arranged in an open spiral, and in addition to these their surface frequently shew faint reticulations. Calyculus spinulose within. Spores pale by transmitted light, very slightly roughened, $7—10\mu$ in diameter.

A common species occurring on decaying wood of various conifers.

29. *Arcyria incarnata,* Persoon.—Sporangia closely crowded, cylindrical, stipitate, $1—1.5^{mm}$ in total height. Stipe short, about $.25^{mm}$ long, or reduced to a mere point beneath the calyculus, dark colored, furrowed and filled with spore-like cells. Calyculus plicate to the margin and spinulose.

Capillitium a loose net of pink or rose-colored threads, 3—3.5 μ wide, attached by a few strands which run to the centre of the stipe. The strands or tubules are marked with rather distant cogs and half rings arranged in an open spiral. Perforated plate-like expansions are found here and there at the nodes, more particularly in the lower portion of the net. Free ends are occasionally found but are rare. Spores colorless by transmitted light, almost smooth or slightly roughened and with a few scattered warts, 7—8 μ in diameter.

A common species found on decaying *Populus tremuloides*, *Fagus ferruginea* and *Abies balsamea.*

30. *Arcyria denudata* (Linn.) Sheldon.—Sporangia gregarious, cylindrical stipitate; total height with expanded capillitium 3—4^{mm}. Stipe about 1^{mm}, filled with spore-like cells 12—14 μ in diameter. Calyculus plicate, smooth; capillitium, a net of rosy threads fading to dusky yellow, 3—4 μ wide and adorned with distant cogs and half rings arranged in the form of an open spiral. Near the calyculus the threads are almost smooth. The capillitium is attached to the calyculus at many points and hence is not deciduous. Spores colorless by transmitted light, smooth, about 7 μ in diameter.

Found on decaying conifers; not rare.

31. *Arcyria cinerea* (Bull.) Pers.—Sporangia gregarious, cylindrical or somewhat broader at the base, stipitate, ash colored. Stipe variable in length, in some gatherings .75^{mm} long, in others, the sporangia are almost sessile. Total height of sporangia with expanded capillitium, 2—2.5^{mm}. Stipe dark, of almost uniform thickness, hollow, filled with spore-like cells. Calyculus plicate at the base. Capillitium a close net attached at many points to the calyculus. The peripheral portions of the net consist of threads or tubules 3—3.5 μ wide adorned with close-set spines and presenting many plate-like expansions at the nodes and elsewhere. The interior portions of the net and also the part near the calyculus consist of tubules somewhat wider

and almost smooth. Spores colorless by transmitted light, granular, 6—7 μ in diameter. The fructifications of this species are with us frequently large, in some cases, extending over an area 20—30^{cm} long and several centimetres wide, with numerous sporangia.

A fairly common species found on the decaying wood of various deciduous and coniferous trees.

Family, TRICHIEÆ.

Capillitium consisting of free elaters or of tubules connected to form a loose net with many free ends. The elaters or tubules are marked with spiral thickenings.

This family is represented in my collections by six species, three of the genus *Hemitrichia* and three of the genus *Trichia*.

Genus, **Hemitrichia** Rost.

Capillitium consisting of a net of branching anastomosing tubules with many free ends, and marked with regular spiral thickenings.

32. *Hemitrichia vesparium* (Batsch) Macbr.—Sporangia crowded, sessile, clavate, of a deep red color and with a metallic lustre. Capillitium a loose net of orange colored threads about 6μ wide with numerous free ends. The threads are adorned with a number of spiral bands and beset with numerous long spines. Spores yellowish by transmitted light, strongly warted, 10—11 μ in diameter.

On decaying *Populus trenuloides*. Rare.

33. *Hemitrichia stipata* (Schw.) Macbr.—Sporangia closely crowded on a well developed hypothallus, stipitate, cylindrical or somewhat irregular from mutual pressure. Copper colored and shining when fresh becoming dark red brown when old. Total height about 1.5^{mm}. Stipe short, .5^{mm} in length, dark red brown, striate, hollow, filled with spore-like cells. The lower part of the peridium persists as a plicate calyculus to which the capillitium is attached at a few points. Capillitium a loose net

with many free swollen ends, the threads beset with short spines, and adorned with a number of very faint spiral lines. The threads or tubules are about 3.5 μ wide. Spores colorless by transmitted light, marked with a few small scattered warts, 6.5—8.5 μ in diameter.

On decaying *Populus grandidentata.* Not common.

34. *Hemitrichia stipitata* Massee.—Sporangia scattered, stipitate, obovoid, dusky yellow. Total height with expanded capillitium about 2.5^{mm}. Stipe about one-half the total height, dark colored, hollow, filled with spore-like cells. The lower portion of the peridium persists as a calyculus extending to about one-third the height of the capillitium, its interior surface covered by minute papillæ. The capillitium consists of a close net of even brown threads, 6—6.5 μ wide, adorned with a number of regular spiral ridges, somewhat closely wound. Free ends are not evident. Spores colorless by transmitted light, minutely warted, about 7 μ in diameter.

On decaying *Pinus strobus.* Common.

Genus, **Trichia** (Haller) Rost.

Capillitium of free elaters, simple or branched, and adorned with a number of spiral ridges. Sporangia sessile or stipitate. Spores generally yellow.

35. *Trichia inconspicua* Rostafinski.—Sporangia gregarious, small, spherical, ellipsoid reniform or arcuate, sessile, red brown in color. The elaters are brown, simple, 3—4 μ wide, marked with a number of close-wound spiral ridges projecting sharply. The ends are somewhat swollen behind the curved or hooked tips which are sometimes bifurcated. Spores yellowish by transmitted light, papillose, about 10 μ in diameter. The gathering which I have referred to this species combines many of the characteristics of *Trichia inconspicua* Rost., and *Trichia contorta* (Ditmar) Rost, as given by Dr. Macbride (N. A. Slime moulds, pp. 210, 211.) The sporangia shew a strong tendency

to form elongated, curved plasmodiocarps, while the elaters are long, slender and even (with the exception of the extremities), and the spirals regularly wound. The extremities, on the other hand, are frequently swollen behind the curved tips.

On the inner side of fallen bark of *Fagus ferruginea.* Rare.

36. *Trichia varia* (Pers.) Rost. — Sporangia closely crowded, spherical, or contorted, dusky yellow, shining when fresh, sessile, about .75^{mm} in diameter when regular. Elaters simple, 4—5μ wide, somewhat irregular in outline, marked with two spiral ridges irregularly wound and projecting sharply. They narrow abruptly at the ends, which are 12—14μ long and marked almost to the tips with faint spiral lines. Immediately behind the ends, the elaters sometimes show a slight enlargement and spinous outgrowths, sometimes curved, are not uncommon. The ends also sometimes terminate in two or three sharp tips. Spores pale yellowish by transmitted light, almost smooth, 13—14μ in diameter.

On decaying *Populus grandidentata.* Not common.

37. *Trichia decipiens* (Pers.) Macbr.—Sporangia closely gregarious, obovoid dusky yellow or olivaceous yellow, stipitate; total height about 2^{mm}, diameter .8^{mm}. Stipe furrowed, hollow, filled with spore-like cells. Elaters simple, about 5μ wide, marked with three spiral ridges not traceable to the ends which are long and tapering. Spores almost colorless by transmitted light, reticulated, 11—12μ in diameter.

On decaying *Populus grandidentata.* Not common.

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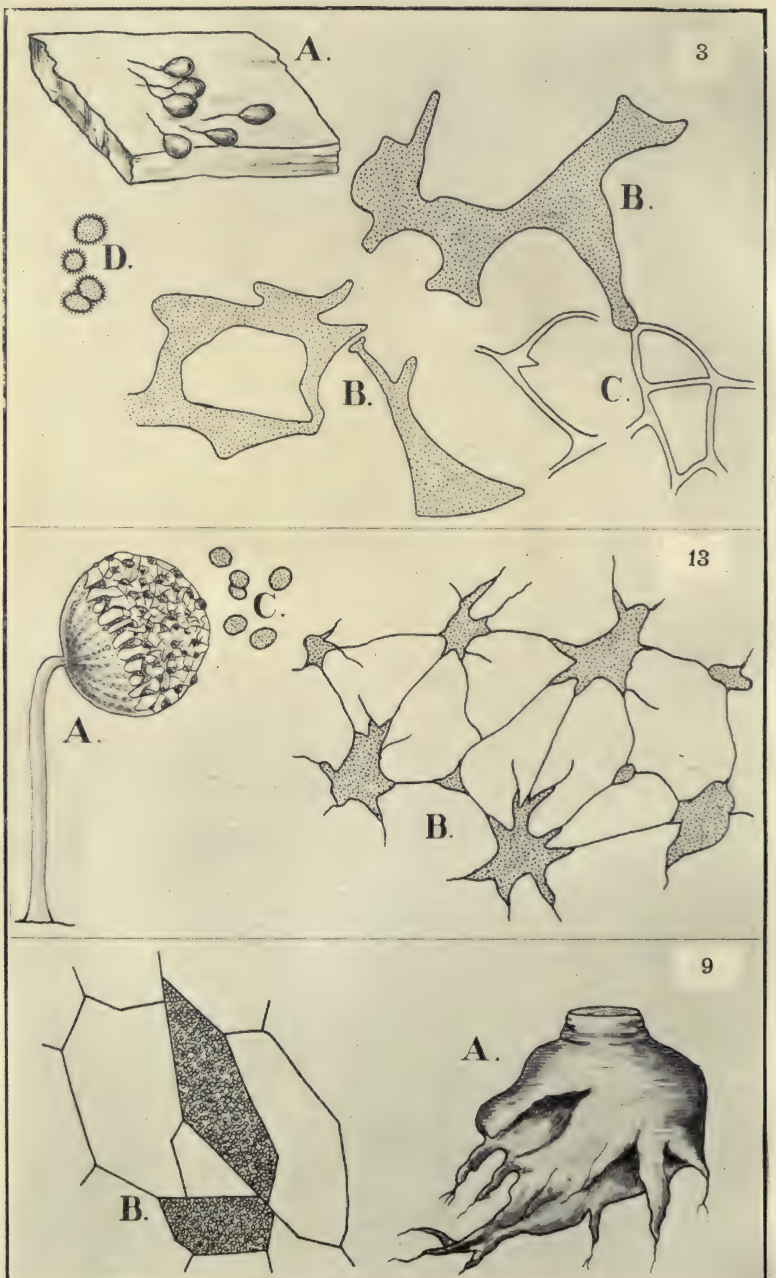
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EXPLANATION OF PLATE IX.

3.—*Leocarpus fragilis* (Dicks.) Rost. A.—Sketch of a few sporangia shewing habit of growth. B.—A portion of that part of the capillitium filled with granules x 166. C.—Portion of hyaline part of same x 166. D.—A group of spores x 166.

13.—*Cribaria macrocarpa* Schrad. A..—Sketch of a sporangium. B.—Portion of wall of sporangium after spore dispersal taken from upper part of net x 166. C.—Spores x 300.

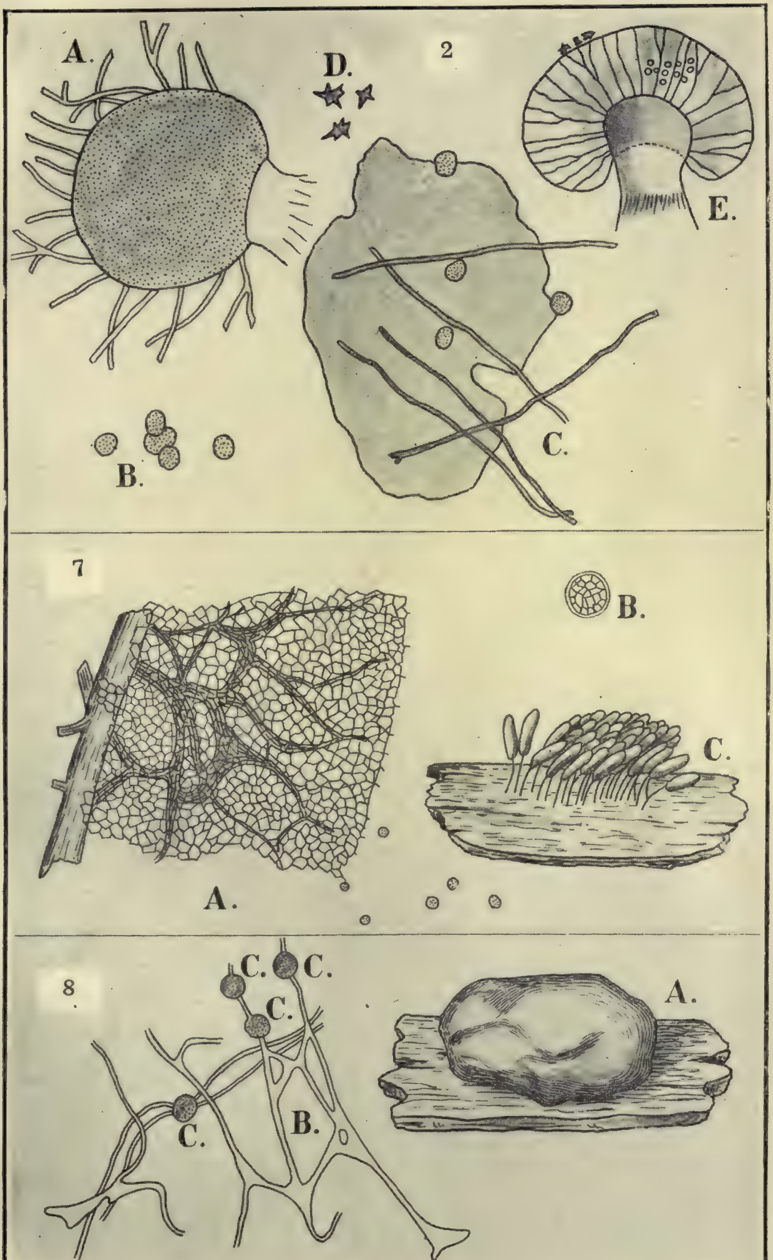
9.—*Plasmodiophora brassicae* Woron. A.—Sketch of a turnip shewing distorted growth due to parasite. B.—Portion of a section through one of the irregular swellings shewing cells filled with the spores of the species x 300.

EXPLANATION OF PLATE X

2.—*Didymium melanospermum* (Pers.) Macbr. A.—Columella shewing origin of capillitial filaments x 33. B.—Spores x 250. C.—Portion of the peridium with capillitial threads attached x 166. D.—Stellate lime crystals from peridium. E.—Diagrammatic section of sporangium shewing relations of columella, capillitium and peridium.

7.—*Stemonitis maxima* Schweinitz. A.—Portion of columella and capillitium x 500. B.—Spores x 500. C.—Sketch of cluster of sporangia, shewing habit of growth.

8.—*Fuligo ovata* (Schaeff.) Macbr. A.—Sketch of an aethalium shewing habit of growth. B.—Portion of capillitium x 300. C.—Spores x 300.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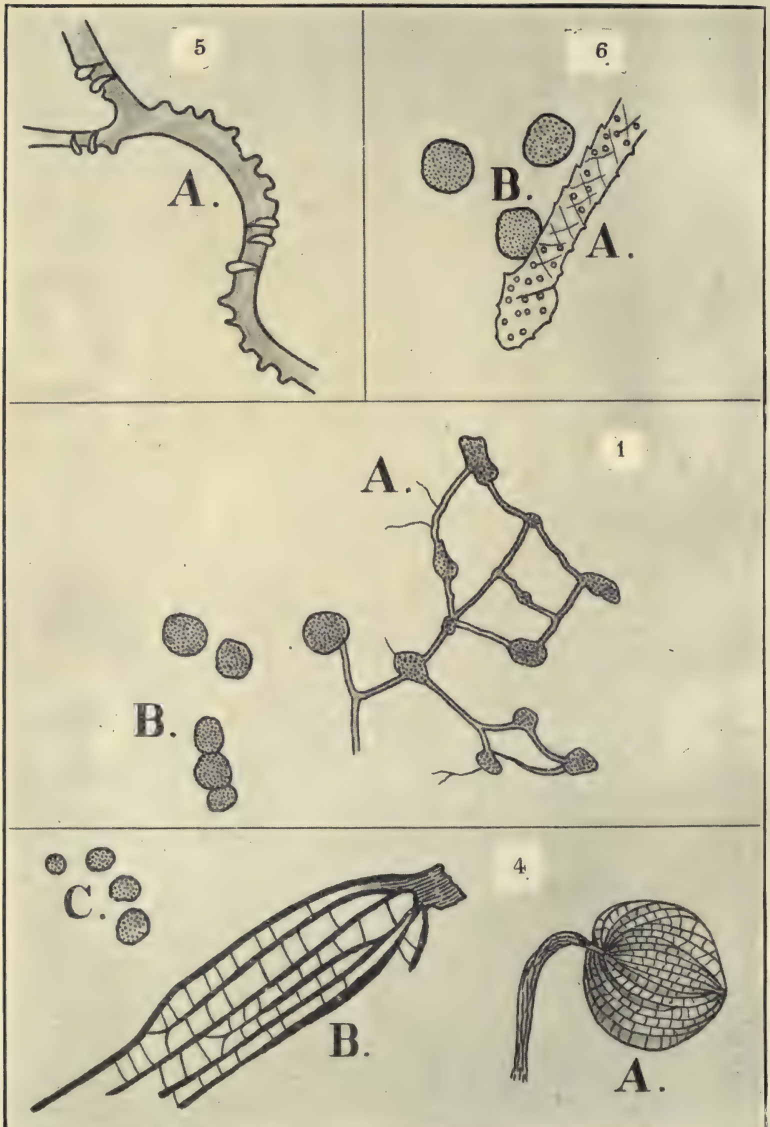
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EXPLANATION OF PLATE XI.

5.—*Arcyria denudata* (Linn.) Sheldon. A.—A portion of tubule of capillitial net.

6.—*Hemitrichia stipata* (Schw.) Macbr. A.—Free end of a capillitial tubule x 450. B.—Spores x 450.

1.—*Physarum globuliferum* (Bull) Pers. A.—Portion of capillitium. B.—Spores x 450.

4.—*Dictydium cancellatum* (Batsch) Macbr. A.—Sketch of sporangium and upper part of stipe. B.—A portion of the wall of a sporangium after spore dispersal x 250. C.—Spores.

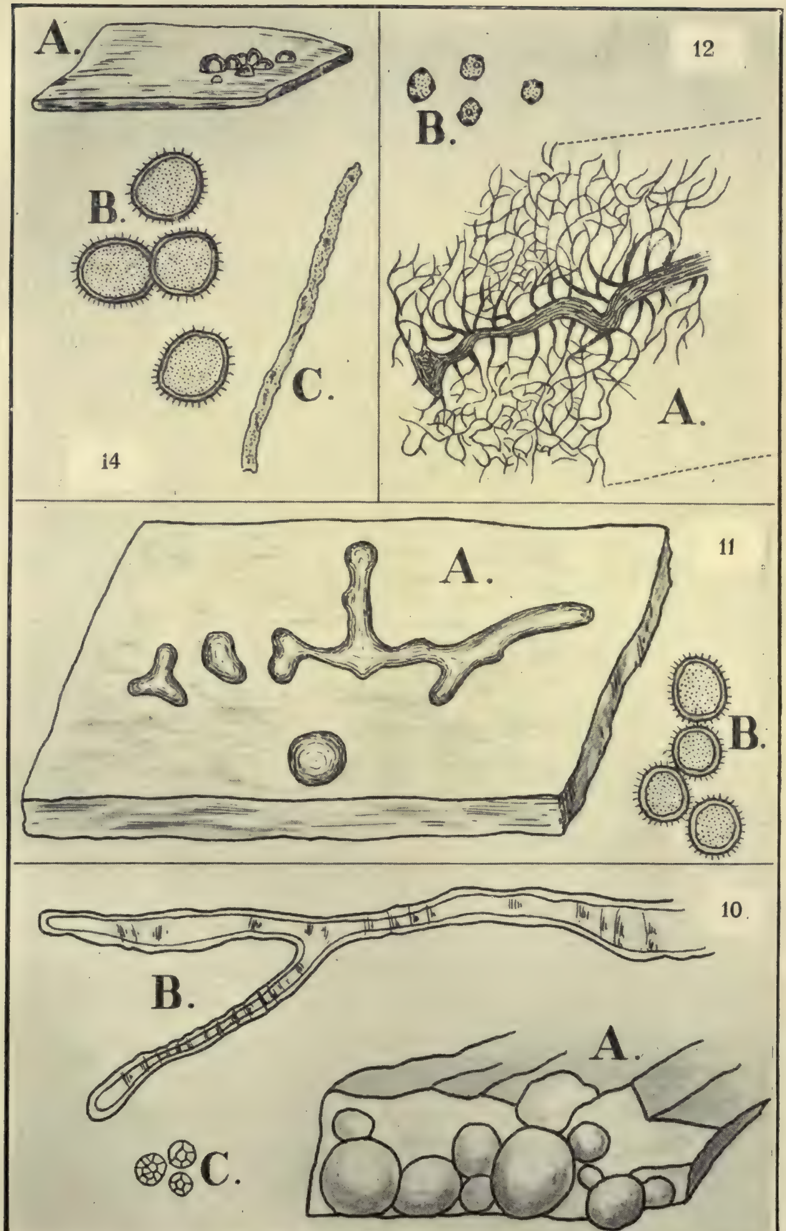
EXPLANATION OF PLATE XII.

14.—*Margarita pictoviana* Sp. nov. A.—Group of sporangia shewing habit of growth. B.—Spores x 750. C.—Portion of capillitial thread x 750.

12.—*Comatricha stemonitis* (Scop) Sheldon. A.—Terminal part of columella and capillitium in one collection made x 96. B.—Spores of same x 450.

11.—*Licea variabilis* Schrader. A.—Sketch of plasmodiocarpous fructification x 8. B.—Spores x 450.

10.—*Lycogala epidendrum* (Buxb.) Fries. A.—Sketch shewing a cluster of aethalia. B.—Portion of a capillitial tubule shewing free ends. C.—Spores.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THE INFLUENCE OF ALUMINIUM SALTS ON THE ESTIMATION OF SULPHATES.—BY H. JERMAIN M. CREIGHTON, M. A., Birmingham University, Birmingham, England.

Read 24th April, 1909.

During an experience extending over three years, in the estimation of sulphur in coal gas, the writer at various times observed the presence of a flocculent white precipitate in the liquid which resulted from the condensation of the vapours formed by the burning of the gas. The following investigation was therefore carried out with a view to determining the nature of this precipitate and the influence its presence had on the estimation of the sulphur present in the liquid. It may be mentioned here that the amount of sulphur in coal gas was determined by burning a known volume of the latter in a special burner which was surrounded with lumps of ammonium carbonate. Over the burner fitted a large glass tube, up which the gases of combustion passed into a glass tower filled with glass balls. On coming in contact with the cold balls, the sulphur dioxide, ammonia, water vapour, etc., condensed and were caught in a beaker placed beneath the tower. After oxidation, the sulphur in this liquid was determined by precipitation with barium chloride. It was in this liquid which I shall refer to as the "sulphur solution," that the white flocculent precipitate referred to was frequently observed.

It should be pointed out that the coal from which the gas was generally made was that supplied by the Dominion Coal Co., in Cape Breton; and that analysis showed it to be very often high in sulphur. On several occasions where different American coals low in sulphur were used, no such precipitate occurred.

This white precipitate readily dissolved in dilute hydrochloride acid, and was re-precipitated by ammonium hydroxide

but not by sodium hydroxide. On heating some of the washed precipitate on charcoal, allowing it to cool, and heating again after moistening with cobalt nitrate solution, the mass became sky blue on cooling a second time. A qualitative analysis proved this precipitate to contain aluminum only.

As the only source of aluminium seemed to be the glass balls in the condensing tower, many of the bottom ones being greatly corroded, an analysis of them was made. The sodium carbonate used for fusing was free from aluminium. These balls were found to contain a quantity of aluminium.

The weight of this white precipitate which was present in the alkaline "sulphur solution" in the form of hydroxide, usually varied from 10 to 40 milligrams.

Peckham* has observed that when sulphates are precipitated by barium chloride in the presence of aluminium, the precipitate is contaminated with aluminium, and hence its weight is greater than that which corresponds to the actual amount of sulphur present. This case is similar to that which occurs in the precipitation of sulphates in the presence of ferric salts. The following experiments were carried out to determine whether the amounts of aluminium usually present in the "sulphur solutions" caused any marked error in the sulphur estimation.

Two sets of experiments were carried out. On the one hand, varying amounts of an aluminum salt were added to constant amounts of sulphate solution; on the other hand, constant amounts of the aluminium salt were added to varying quantities of the sulphate solution. The sulphate in each case was determined by precipitation with barium chloride.

The sulphate used was the ammonium salt. The strength of this solution was about ten grams per litre. The object of using the ammonium salt was to reproduce as far as possible the conditions existing in the above mentioned sulphur estimation.

The aluminium salt used was the chloride. This solution, which was prepared by dissolving pure aluminium in hydro-

*Peckham J., Amer. Chem. Soc., 1899, 21, 772.

chloric acid, contained one gram per litre ; or 1 cc. was equivalent to one milligram of the metal.

The precipitation of the sulphate was carried out at 100° C., and the precipitate was allowed to digest in the hot (80—90° C.) liquid for three or four hours before filtering.

The results given in the following tables are the means of three analyses.

The experimental error in this work is ± 0.0008 grams.

In the first table are given the results obtained by adding various amounts aluminium chloride solution to 50 cc. of ammonium sulphate solution.

TABLE 1.

Volume of Ammonium Sulphate Solution used.	Volume of Aluminium Chloride Solution used.	Weight of Barium Sulphate Precipitate.	Increase in Weight due to the presence of Aluminium.
cc.	cc.	grams	grams
50.00	....	0.8649	....
50.00	10.00	0.8651	0.0006
50.00	15.00	0.8672	0.0023
50.00	20.00	0.8699	0.0050
50.00	25.00	0.8714	0.0065
50.00	35.00	0.8710	0.0061
50.00	50.00	0.8711	0.0062

The second table gives the results obtained by adding a constant volume of aluminium chloride solution to different volumes of ammonium sulphate solution.

TABLE 2.

Volume of Ammonium Sulphate used.	Volume of Aluminium Chloride used.	Weight of Barium Sulphate Precipitate.	Increase in Weight due to the presence of Aluminium.
cc.	cc.	grams	grams
10.00	....	0.1729	....
10.00	25.00	0.1738	0.0011
30.00	....	0.5193	....
30.00	25.00	0.5235	0.0042
50.00	....	0.8650	....
50.00	25.00	0.8714	0.0064
80.00	....	1.3838	....
80.00	25.00	1.3950	0.0112
100.00	....	1.7362	....
100.00	25.00	1.7501	0.0139

From the foregoing results, it is seen that the effect of the presence of small quantities of aluminium chloride is to produce a material increase in the weight of the barium sulphate precipitate. With increasing amounts of aluminium chloride and a constant amount of sulphate present, the weight of aluminium taken up by the barium sulphate at first increases and then remains constant, while in the second case, where the amount of sulphate is varied, the degree of contamination of the barium sulphate is proportional to the weight of sulphate used. These results are similar to those obtained by Schneider* for iron. In a solution containing 0.5 gram of ammonium sulphate and 0.025 gram of aluminium there would be an error of about 1 per cent. in the estimation of the sulphur present, as carried out in the ordinary way.

Although it is well known that ammonium carbonate cannot be kept in clay or stoneware jars on account of its action upon them, the presence of ammonium carbonate round the gas burner is not sufficient to explain the corrosion of the glass balls in the

*Schneider, E. A., Zeit. f. physik. Chem., 1892, 10, 425

condensation tower; for if such were the case one would expect to find aluminium hydroxide continually present in the "sulphur solution" instead of only occasionally. It is important to note that this aluminium precipitate only occurs when the gas contains a large quantity of sulphur, which I may mention is mostly present in some organic form. This consideration leads me to believe that there is probably a connection between the formation of this aluminium hydroxide and the amount of sulphur, and the condition in which it exists, in the coal; more especially as the Cape Breton coals contain, for the most part, a large percentage of sulphur organically combined, and consequently not completely removed in the purification of the gas, while this is not the case with the American coals referred to. It is hoped in a future paper to give a complete explanation of this behaviour. In conclusion, I would point out the advisability of using glass balls that are free from aluminium, in determining sulphur in coal gas by the method here described.

Birmingham University, February 26th, 1909.

The Action of Organic Sulphur in Coal during the Coking Process.—By A. L. McCallum, B. Sc., Halifax.

Read 12th February, 1908.

I was led to undertake this investigation by the conflicting statements of the authorities as to the action of organic sulphur during the coking process. Some say that the whole of the organic sulphur remains in the coke, others that part is volatilized, and still others that all the organic sulphur is driven off in the coking process. It is barely possible that all these statements are true of different coals, but I wanted, if possible, to find out what was the case with a typical Nova Scotia coking coal.

It occurred to me that if I could get a series of samples with a decreasing amount of inorganic sulphur and an increasing amount of organic, I would be able to get some data on the above subject, by determining the amount of inorganic and organic sulphur, and at the same time the amounts of volatile and fixed sulphur in the various samples.

It might be well at this point to say a few words as to the manner in which sulphur occurs in coal. To the best of our knowledge sulphur occurs in three forms in coal:—(1) as sulphates; (2) as iron pyrites; (3) as organic sulphur.

The coal used in this investigation was practically free from sulphates so that we have the two latter forms only to deal with.

The action of iron pyrites when subjected to heat without access of air is well known. There is a loss of one atom of sulphur according to the equation $Fe\ S_2 = Fe\ S + S$. The coke oven presents ample time and the necessary conditions for this reaction to be complete.

Not knowing in what state of combination the organic sulphur occurs in coal, it is impossible to say what effect the heat of the coke oven will have. It was, as previously stated, in an attempt to throw some light on this question, that the investigation was undertaken.

Now to return to our coal samples. The only way o obtain such a series of samples as previously mentioned, viz.: with decreasing inorganic and increasing organic sulphur was to fractionate the coal on the basis of specific gravity, that is separate it into several fractions of gradually decreasing specific gravity. The means used to accomplish this were solutions of calcium chloride of varying specific gravities. The coal used was crushed to pass through $\frac{1}{12}$ inch mesh screen and was then placed in a vessel containing a solution of calcium chloride of slightly higher specific gravity than that of the coal.

For instance, the raw coal was found to have a specific gravity of 1.323. For this a calcium chloride solution of 1.35 specific gravity was used. This separated the coal into two fractions having the following specific gravities: the lighter material 1.275, and the heavier 1.731.

Part of this lighter or floating fraction was reserved for analysis and the remainder was treated with a calcium chloride solution of lower specific gravity. This procedure was kept up until, at a specific gravity of 1.24, there was no floating fraction.

Between these two extremes I obtained five fractions of the following respective specific gravities:

No. 1	1.323
No. 2	1.275
No. 3	1.261
No. 4	1.253
No. 5	1.243

The proximate analyses of these samples are as follows:—

TABLE I.

No.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Sulphur in coke.
1	35.10	59.74	5.16	2.06	1.80
2	35.92	61.57	2.51	1.29	1.17
3	36.10	62.27	1.63	1.09	.85
4	37.47	61.50	1.03	.95	.78
5	37.75	61.35	.90	.88	.68

The only method at present available for the determination of the organic sulphur in coal is by difference, and there is one inherent source of error which, however, I think is not material. The method referred to is as follows:—The percentage of iron is determined. Then this iron is combined with the necessary amount of sulphur to form iron pyrites ($Fe\ S_2$). This amount of sulphur is deducted from the total amount in the coal and the balance is called organic sulphur.

The error referred to in this method is due to the fact that it is almost certain that there is some iron present as silicate in the "stone and shale" which are always present in the coal. But as the percentage of iron in the "stone and shale" rarely exceeds 3 per cent. and the percentage of stone and shale in the coal under consideration rarely exceeds 5 per cent. of the coal by weight, it will readily be seen that any error introduced will be exceedingly small.

Applying this method to the samples under consideration, we obtain the figures given in Table II.

TABLE II.

No.	Organic sulphur.	Inorganic sulphur.
1	37.86%	62.14%
2	56.59%	43.41%
3	71.56%	28.44%
4	83.16%	16.84%
5	85.23%	14.77%

We have thus clearly obtained a series of samples with gradually decreasing inorganic and increasing organic sulphurs.

There is also another way in which the total sulphur may be distributed, viz.: as volatile and fixed sulphur; meaning of course, that sulphur which escapes during the coking process and that which remains in the coke.

The method used in obtaining this information is to first determine the total sulphur in the coal and then the total sulphur in the coke produced from that particular coal. From this it is easy to calculate the amount of sulphur volatilized.

Table III gives the figures thus obtained.

TABLE III.

No.	Volatile sulphur.	Fixed sulphur.
1	33.49%	66.51%
2	42.64%	57.36%
3	50.46%	49.54%
4	49.47%	50.46%
5	52.27%	47.73%

There is not the same regularity as shown in Table II, but there seems to be an increase in the amount of volatile sulphur in those samples having a high percentage of organic sulphur.

Now if the only sulphur volatilized was the one atom of sulphur in pyrites according to the above mentioned squation, we can calculate what the percentage of volatile sulphur should be; because the sulphur called inorganic is assumed to be present as iron pyrites. So that if we take half the inorganic sulphur it should correspond with the percentage of volatile sulphur if the above supposition is true, and also if there is no organic sulphur volatilized.

The result of this calculation is given in Table IV.

TABLE IV.

No.	One half the Inorganic sulphur.	Volatile sulphur.	Difference.
1	31.07	33.49	2.42
2	21.70	42.64	20.94
3	14.22	50.46	36.24
4	8.42	49.47	41.05
5	7.38	52.27	44.89

This would seem to indicate that when the inorganic sulphur was in excess the above supposition is approximately true, but that it does not hold at all when the organic is in excess. It seems rather strange why this should be so unless it is due to mass action.

I think we are perfectly justified in concluding that in the coking process a very considerable part of the organic sulphur is volatilized.

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TRANSACTIONS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1908-1909

SOME NOVA SCOTIAN AQUATIC FUNGI.—BY CLARENCE L. MOORE, M. A., Sydney, N. S.

Read 11th January, 1909.

The *Saprolegniineæ* constitute a group of the *Phycomycetes* characterized by their possession of a well developed mycelium of more or less richly branched siphonaceous filaments and by the production of two kinds of reproductive bodies, viz. : (1) small, non-sexual spores, generally appearing as warm spores, and (2) sexual spores.

The order has been divided into the following families :

A. Strictly aquatic fungi, with a mycelium of generally stout siphonaceous filaments ; zoosporangia approximately cylindrical, not at all or little broader than the supporting filaments ; sexual fertilization doubtful ; conidia wanting.

a. Vegetable filaments of uniform thickness,

1. *Saprolegniaceæ.*

b. Vegetable filaments constricted at intervals.

2. *Leptomitaceæ.*

B. Fungi with a mycelium of delicate thread-like hyphæ, mostly saprophytic, rarely parasitic, living in water or facultatively in moist air; zoosporangia generally spherical, resembling in form the oogonia and strongly marked off from the vegetative portions of the hyphæ; formation of oospores preceded by a sexual act; conidia present.

3. *Pythiaceæ.*

The zoospores are produced in sporangia and are formed in large numbers by the simultaneous division of the contents of these organs, and, as has been stated, usually escape as swarm spores. In all of the genera of the family *Saprolegniaceæ*, with the exception of *Pythiopsis*, *Dictyuchus*, *Thraustotheca* and *Aplanes*, the swarm spores escape as terminally biciliate zoospores, and soon after their escape encyst. After a period of rest, generally a few hours. they escape from their enclosing membranes and pass through a second swarming stage as more or less kidney shaped laterally biciliate zoospores. After a second encystment germination takes place. This phenomenon is referred to as diplanetism. In *Phythiopsis*, the second swarming stage is suppressed and germination takes place immediately upon the escaping zoospores first coming to rest. In *Dictyuchus*, the zoospores encyst within the sporangia and finally escape, each by a separate opening through the outer wall, and then appear with lateral cilia. In this genus the first swarming stage is suppressed. The same suppression is also found in *Thraustotheca*, and in the genus *Aplanes* the disappearance of the swarming stages is practically complete. Here the spores germinate within the sporangium, the germ tubes pushing out through the wall.

The history of the swarm spores in the family *Leptomitaceæ* has not been so completely worked out, but in the genera *Leptomitus* and *Apodachlya*, they appear to be diplanetic.

In the third family of the order, *Phthiaceæ*, the swarm spores are monoplanetic.

The sexual reproduction in the order is by means of oogonia and antheridia. The former are, as a rule, spherical and terminal on the main filaments or lateral branches, or at times intercalary, when they may be spherical, barrel shaped or cylindrical. The antheridia are cylindrical, club shaped or ovate cells cut off from the ends of special branches which become appressed against the walls of the oogonia, and in some cases at least send through the walls of the latter organs fertilisation tubes. A modification of the common type of antheridium is found in *Saprolegnia hypogyna* Pringsheim, and in *Achlya hypogyna* Coker & Pemberton[1]. In these species an antheridial cell is cut off from the oogonial branch by a septum a short distance below the basal wall of the oogonium, and a tube-like growth from this basal wall pushes up directly into the cavity of the latter organ. In some forms antheridia are absent, and it appears to be doubtful whether in the great majority of the first two families of the group, even when they are present, they have not become functionless. The contents of an oogonium gives rise to one or more oospheres which ripen into resting oospores and lie free in the cavity of the oogonium. The ripening process generally occupies two or more weeks. In the ripe condition the fat contents of an oospore usually collect in one or a few large globules. When the oil globule occupies one side of the spore and is not included by the remaining spore contents, the spore is described as "excentric." When the oil globule is surrounded by the other spore contents the descriptive term "centric" is applied. A good example of the first is found in *Achlya americana* Humph., and of the second condition in *Achlya apiculata* DeBary.

The walls of the oogonia may be smooth or provided with more or less numerous outgrowths; they may become uniformly thickened or definite areas may remain unmodified, giving rise to pits. These unthickened areas or pits are best brought out by treatment with chlor-zinc-iodine solution, which gives to the

walls generally a color which has been described as an indian red, while the pits appear as light areas.

The members of the first two families grow in water on decaying vegetable and animal remains, such as dead algæ, sticks, the bodies of insects, etc., and may readily be procured for study by collecting some of the debris and slime from the bottom of any more or less permanent pool and throwing on the water the dead body of an insect such as the common house fly, first sterilized by soaking for a short time in absolute alcohol. In from 24 to 48 hours the body of the fly will generally be found to be covered with a filamentous growth quite visible to the naked eye. Several species will, as a rule, be found to have developed, and so general is the distribution of these forms of life, that, in my own experience, only about one attempted culture in every twenty was a complete failure.

While the *Saprolegniaceæ* are normally saprophytes, various species, of the genera *Saprolegnia* and *Achlya* may become facultative parasites and have been the cause of serious epidemics among fish, the salmon appearing to be particularly susceptible to their attacks. The fungus may develop on various parts of the body of the fish, infesting the eyes and gills and eventually causing blindness and death. The mortality among the fresh water fish in the aquaria of the U. S. Fish Commission at the World's Fair, Chicago, in 1892, was so great as to call for a special investigation when the trouble was found to be due to a *Saprolegnia*, probably *S. mixta*[2].

All of the forms which are herein described and figured belong to one or other of the families, *Saprolegniaceæ* and *Leptomitaceæ*, and were collected during 1907 and 1908 in the vicinity of Pictou, N. S.; Lower Mt. Thom, Pictou Co.; and Sydney, N. S. The number is not large, but the area covered was small and, in addition to those here described, a considerable number of forms appeared in the cultures made which are not referred to; the observations of them not being sufficiently

complete for certain determinations. This paper will, at least, serve to direct the attention of our botanists to the group which will, no doubt, be found to be well represented in our flora.

Family, SAPROLEGNIACEÆ.

In this family the generic divisions are based upon the characteristics of the sporangia and zoospores ; the specific divisions upon the characteristics of the sexual organs. The three genera which have appeared in the cultures made are **Saprolegnia, Achlya** and **Aphanomyces.**

In the first, the zoospores escape from the sporangium by a common mouth and swarm separately. The sporangia are, as a rule, renewed by the filament continuing its growth up through the empty sporangium. A second sporangium may be cut off before the tip reaches the top of the old sporangium and thus several empty sporangia may be found one within the other (fig. 1). In a few cases, the innovation of sporangia is by cymose branching.

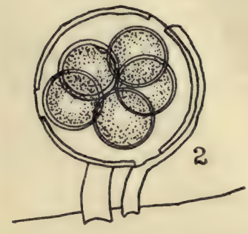
In the genus **Achlya** the zoospores, on escaping from the sporangium, collect to form a hollow sphere at its mouth and there encyst (Fig. 16). The sporangia are renewed by the filament containing its growth by a lateral branch arising at the base of the old sporangium (Figs. 10 & 16). In both of the preceding genera the swarm spores are produced in an indefinite number of rows in the sporangia.

In **Aphanomyces,** the zoospores are produced in a single row, and after escape encyst at the mouth of the sporangium in the same manner as in the genus **Achlya.** In this genus, too, the rule is that but one oospore is produced in an oogonium, while in **Saprolegnia** and **Achlya** the number is generally indefinite within certain limits.

Genus, **Saprolegnia** Nees von Essenbeck.

S. monoica Pringsh. (Figs. 1 and 2). Hyphæ robust, generally not very long. Sporangia cylindrical. Oogonia abundant, spherical, on short generally straight lateral branches or terminal on the main filaments. Walls with very large pits, oospores 2-12, usually 4-6 ; 24μ-27μ in diameter, centric. Antheridial branches, rather stout, arising from the main filaments near the oogonial branches, one or more to each oogonium. Antheridia nearly cylindrical, long and partially encircling the oogonium.


1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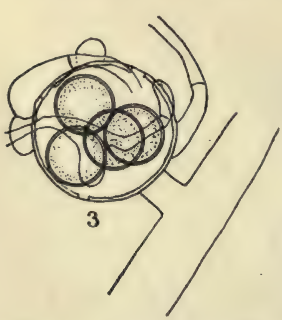
This species appeared in a culture made from material taken from a swamp alongside Columbus Avenue, in the city of Sydney, in May, 1908, and in November of the same year in a culture made from a collection from a pool near the Washing Brook in the same town.

S. diclina Humph. (Fig. 3). Hyphæ as a rule not very long, rarely exceeding .5$^{cm.}$. Sporangia cylindrical. Oogonia spherical, terminal on short straight lateral branches or on the main filaments, rarely intercalary. Walls pitted, but the pits are small and inconspicuous. Oospores 4-25, generally 8-10 in an oogonium ; 22μ-26μ in diameter, centric. Antheridial branches of diclinous origin, delicate. Numerous antheridia attached to each oogonium, short clavate.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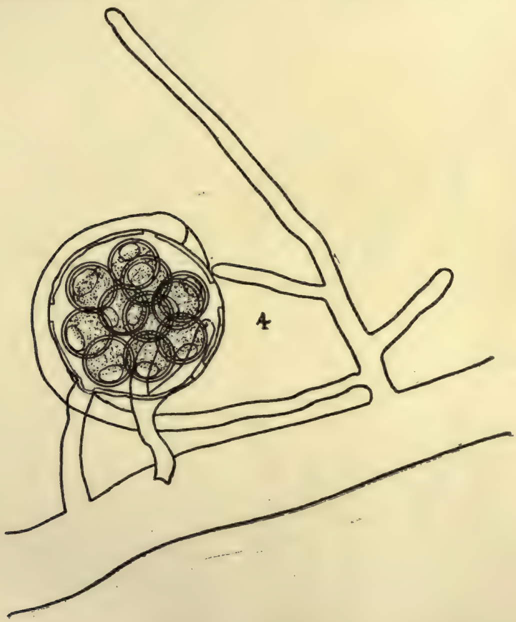
This species appeared in cultures made from material taken from a small brook flowing from Kehoe's Lake, near Sydney, and also from material collected at Cossitt's Lake.

Genus, **Achlya** Nees von Essenbeck.

A. americana Humph. (Fig. 4.). Hyphæ long, robust. Sporangia abundantly developed, nearly cylindrical. Oogonia spherical, on short, straight lateral branches racemosely arranged. Walls more or less abundantly pitted. Oospores up to 15 in an oogonium, 23μ-27μ in diameter, excentric. Antheridial branches abundant, arising from the main filaments near the

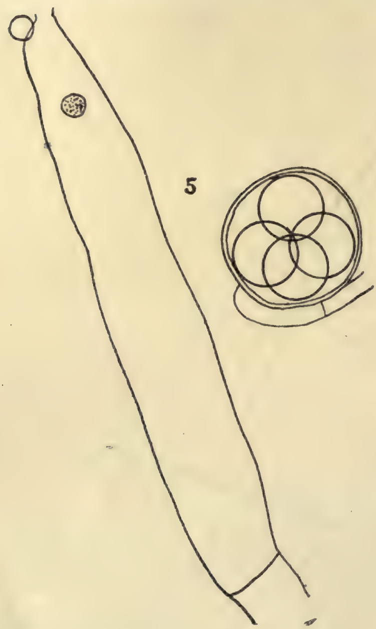


oogonial branches, generally much branched. Antheridia cylindrical, encircling to a greater or less extent the oogonia usually several to each oogonium.

Typical representatives of this species were obtained at Mt. Thom, Pictou Co., and also from a swamp adjacent to Sullivan's Brook, near Sydney. From material collected at Cossitt's Lake, near the same town, there developed a form which may be found to be worthy of varietal rank. In it the walls of the

oogonia were covered with short, blunt, wart-like outgrowths, and the supporting branches of the oogonia were shorter than the typical form. Its characteristics remained constant through several generations, but it was obtained only from the one source. It appears to agree very closely with Trow's *A. americana* var. *cambrica*[3].

A. deBaryana Humph. = *A. polyandra* deBary (Figs. 5-8). Hyphæ robust and long, reaching one centimetre. Sporangia produced in moderate numbers — somewhat spindle shaped, with a longer tapering apex than in most Achlyas, often developed in basipetal succession. Oogonia spherical, terminal on short, straight lateral branches, racemosely arranged or on main filaments. Walls thickened, but not pitted. Oospores 2-10 in an oogonium, usually 2-5; 23μ-35μ in diameter, excentric. Antheridial branches produced on filaments bearing oogonia, very long and much branched, the branches uniting indifferently with oogonia borne on the same filament or on others. The antheridia are long, cylindrical or slightly clavate and wrapped about the oogonia—several to each.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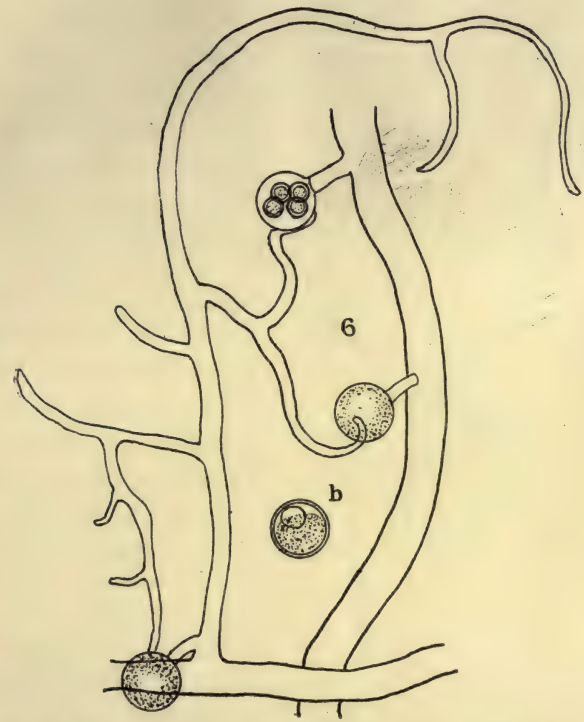
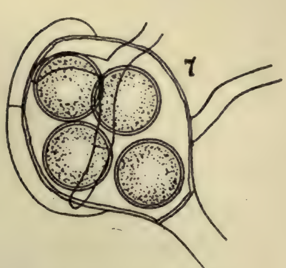
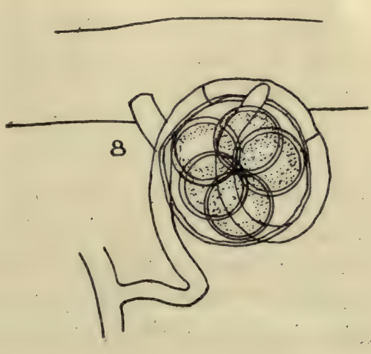
The material in which this species appeared was taken from a pool near the Grand Lake Road, Sydney, near a large brook flowing into Grand Lake. The walls of the oogonia, while not definitely pitted, show a few small more lightly stained areas

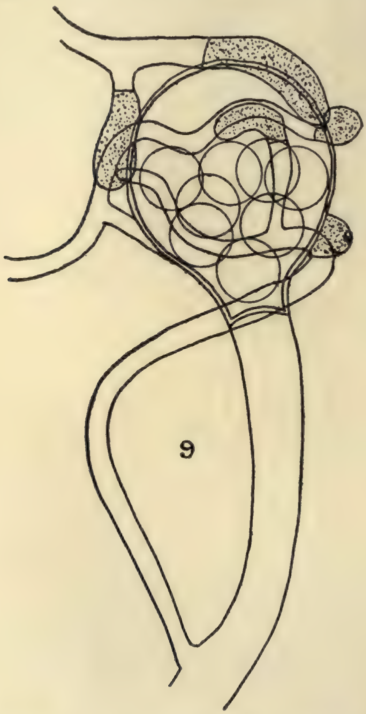


when treated with chlor-zinc-iodine, indicating thinner portions probably where the germ tubes have penetrated. This is said to be one of the commonest European species, but has not before been described from America.





A. polyandra Hild. (Fig. 9). Hyphæ robust and long, frequently exceeding a centimetre in length. Sporangia somewhat spindle shaped, not very abundant. Oogonia terminal on rather long lateral branches which are generally curved and at times helically coiled, or terminal on the main filaments. Walls not much thickened, smooth and unpitted, slightly brownish when old. Oospores 1-20 in an oogonium, commonly 8-12; 23-30μ in diameter, centric. Antheridial branches arising from the oogonial branches or from the main filaments near them, generally more or less branched. Antheridia usually short clavate, several to each oogonium.



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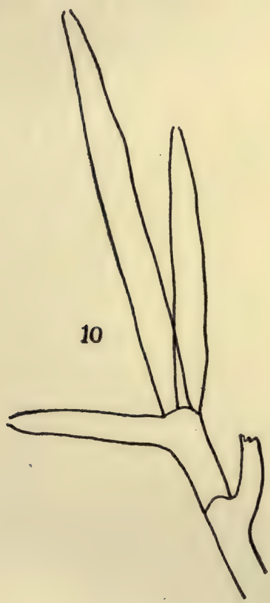
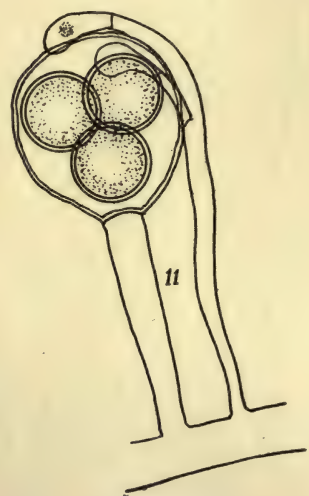
This species appeared on materials collected from a number of sources at Lower Mt. Thom, Pictou county, and appeared to be the most common of the *Saprolegniaceæ* in that district. In young cultures the oogonia are spherical, but in old cultures, when they are being abundantly developed, they frequently become more or less irregular in shape-ovate or obovate. This characteristic was constant in a large number of cultures made. Not infrequently, too, an apiculus appeared on an oogonium. This species appears to be very closely related to the next, differing from it principally in the smaller size and greater numbers of its oospores, in the more branched character of the antheridial branches, and in the more abundant production of sporangia. In old cultures, as in

A. apiculata, the oogonial branches frequently branch, each twig terminating in an oogonium. Rarely an intercalary cylindrical oogonium has occurred in cultures.

A. apiculata deBary (Figs. 10-13). Hyphæ stout, at times considerably exceeding 100μ in diameter at the base and reaching $1.5^{cm.}$ in length. Zoosporangia generally very abundant, somewhat spindle shaped. Oogonia spherical or slightly ellipsoidal,

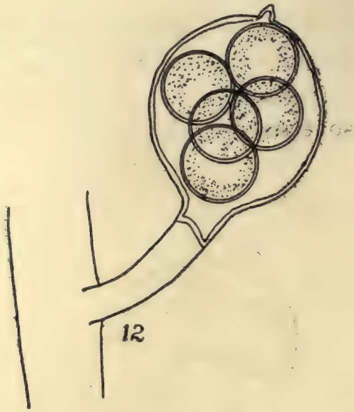




terminal on lateral branches, racemosely arranged and usually curved; rarely intercalary; commonly terminating in a short apiculus. Walls smooth and unpitted. Oospores 1-10, generally 3-5 on an oogonium, large and dark-colored when young, $33\text{-}40\mu$ in diameter, centric. Antheridial branches arising as in the last species, but frequently unbranched. Antheridia, several to each oogonium, short clavate or almost ovate.

This species appeared in a large number of cultures made from materials collected at Mt. Thom, Pictou county, and in

the vicinity of Sydney. It appears to be one of our most common *Saprolegniaceæ.* The frequency of the development of an



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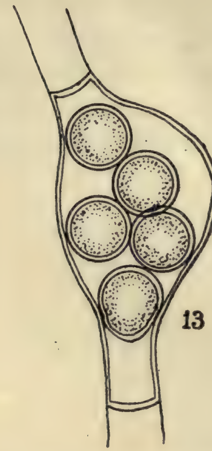

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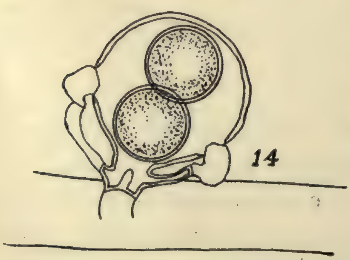
apiculus appears to vary considerably in cultures obtained from different sources. In some, practically all of the oogonia are so terminated, while in others not more than one in three is so furnished.

A. racemosa Hildeb. (Fig. 14). Hyphæ of moderate length, robust. Sporangia generally abundantly produced, cylindrical.



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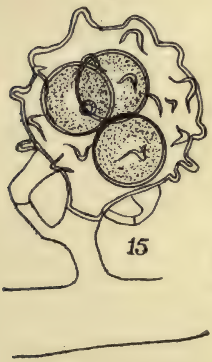
Ooogonia terminal on main filaments and on lateral branches, racemosely arranged. Walls unevenly thickened, but not pitted, brownish when old. Oospores 1-6 in an oogonium, most commonly 3-4, 23μ-30μ in diameter, centric. Antheridial branches arise from the oogonial branches or from the walls of the oogonium or occasionally from the main filament near the oogonial branches. Antheridia 1-3 to each oogonium, short clavate, turned at right angles to the

long axis of the antheridial branch and applied by their apices to the walls of the oogonium.

This species appeared in material taken from the Columbus Avenue swamp, Sydney, and from various other sources near the same town. The irregularly thickened walls of the oogonia and the antheridia are very characteristic. It is not of rare occurence in cultures, but, in my experience, has not appeared so frequently as the following well marked variety.

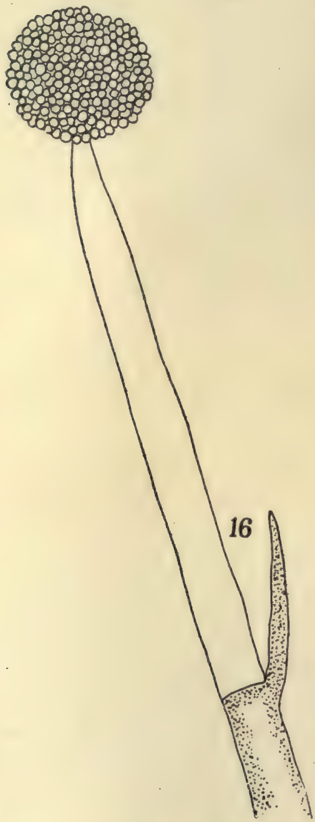
A. racemosa var. *stelligera* Cornu (Fig. 15). This variety differs from the type in that the walls of the oogonia are more or less closely beset with short, rounded outgrowths. The number of oospores varies from 1-7. Their average diameter is, in my experience, somewhat greater than in the type and the antheridial branches appear to take their origin more frequently from the walls of the oogonia. As has been stated the form appears to be more common than the type in the districts from which collections were made.



A. acadiensis sp. nov. (?). (Figs. 16-19). Hyphæ generally very stout and long, frequently exceeding 100μ in diameter and attaining a length of $1.5^{cm.}$.

Zoosporangia almost cylindrical or somewhat fusiform, sparingly developed, in some cultures rare. Oogonia terminal on main filaments or on usually long lateral branches or intercalary. The oogonial walls are provided with more or less numerous blunt outgrowths, sometimes comparatively long, and the terminal oogonia have, as a rule, strongly developed apiculi. The oogonia, in older cultures, are produced in series, frequently 5-7 in a chain. The intercalary oogonia are barrel-shaped or cylindrical. In addition to the outgrowths the walls of the oogonia are also pitted. The oospores may reach 40 in an

oogonium, are centric in structure and measure from 30-35μ in diameter. Antheridial branches are rarely absent, generally two or three arising from the filament



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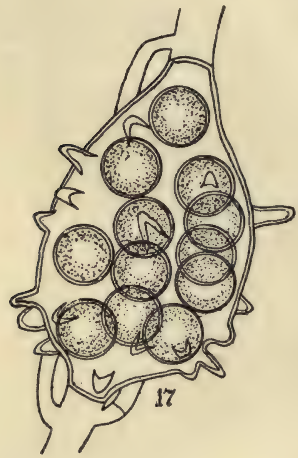

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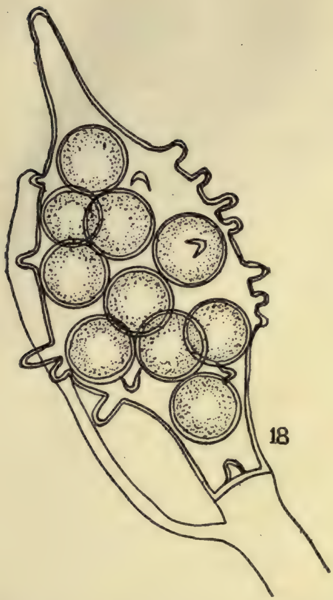
a short distance below the basal wall of the oogonium. These are often branched. Antheridial branches from adjacent filaments not infrequently attach themselves to an oogonium, The antheridia are almost cylindrical or slightly clavate, comparatively long.

This species is the largest and most striking of the Achlyas observed and, in the vicinity of Sydney, is apparently one of the most common. It also appeared in material collected in a pool on the "Barren" near Pictou, N. S. The filaments are unusually stout in vigorous cultures, sometimes reaching 140μ in diameter at the base, and at times attaining a length of almost 2$^{cm.}$ This species appears to be more sensitive than

most *Achlyas* with regard to the behaviour of the zoospores. When a culture is placed in a small quantity of water in a watch glass all of the sporangia



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may fail to empty and the zoospores germinate after the manner of an *Aplanes.* Under such circumstances the germ tubes shew a rapid growth of from 30-40μ per hour. In other cases, where the environment does not appear to be favorable to normal developement, the zoospores may escape and, after the first encystment, germinate without a second swarming stage, as appears to be normal manner in *A. aplanes* Maurizio[4]. Cultures of the species were made for some months in water containing a few living sphagnum plants, and under these conditions the zoospores invariably followed the normal course. At will, the *Aplanes* condition could be induced by removing the culture for a few hours to a watch glass, but it soon disappeared upon return to its original habitat. When oogonia are produced in a chain or series the antheridial branches attached to the distal members of the series take their origin from the walls of the oogonia next below, as in the case of *Saprolegnia androgyna* Archer[5], (*Aplanes braunii* deBary). The number of oospores in the first formed oogonia on the main filaments or large branches is generally large, ranging from 8—15, and frequently from 15—25. In old

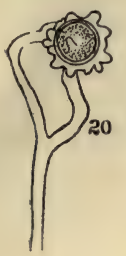
cultures the larger filaments or branches may give rise to fine branches terminating in oogonia containing only one or two oospores and with walls, showing but a few blunt protuberances. In one culture this species was attacked by a parasite identical with or closely resembling *Olpidiopsis saprolgniæ* A. Braun.

A species which bears a very close resemblance to the present one is that described and figured by Dr. Humphrey[6], as *Saprolgnia treleaseana.* The generic position of that species was determined from the observation of one empty sporangium by Dr. Trelease. Its vegetative habit is, according to Dr. Humphrey, very *Achlya* like. In all of the cultures made of A. *acadiensis* the sporangia were produced in sufficient numbers, although sometimes scarce, to render its generic position readily established. Through the kindness of Dr. Johnston, of Johns Hopkins University, I have been enabled to examine the only preparation of *S. treleaseana* in Dr. Humphrey's collection. This preparation shews oogonia and resting sporangia, which correspond closely with those of the present species. No mention is made by Dr. Humphrey of the pitting of the walls in *S. treleaseana* and as the pits are always obscured by the outgrowths, and are generally only evident after treatment with chlor-zinc-iodine, no comparison could be made in this respect between the two species. I have provisionally described the present form under a new name, but further investigation of Dr. Humphrey's species in its type locality may shew that they are identical, in which case the older specific name would prevail, and it would be known as *Achlya treleaseana.*

Genus **Aphanomyces** deBary.

A. stellatus deBary (Fig. 20). Hyphæ delicate, 6μ-7μ wide, little branched. Zoospores forming in a single row and after escape collecting in a cluster at the mouth of the sporangium. Oogonia terminal, the walls with blunt outgrowths giving a star-like appearance. Oospores single, filling the oogonium, 20μ-25μ in diameter. Antheridia present, one to each oogo-

nium, the antheridial branch arising from the same filament as the oogonium, some distance below the latter.

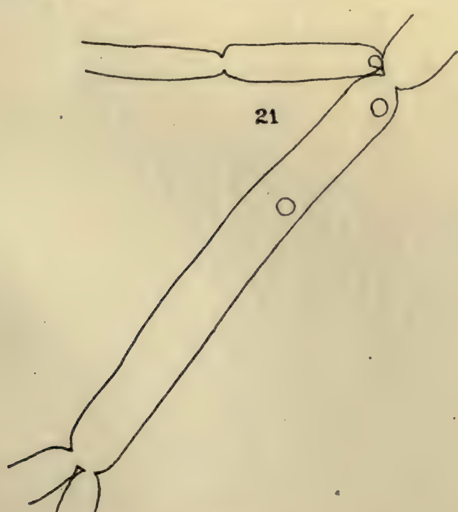


Hyphæ with sporangia, apparently those of an *Aphanomyces*, appeared in several cultures from materials collected at various points near Sydney, but in only one case, from material collected at Cossit's Lake in October, 1908, did oogonia appear. The maximum diameter of the oogonia on the plants examined was about 30μ. I am not aware that this species has been previously reported from America.

Family LEPTOMITACEÆ.

Genus **Leptomitus** Agardh.

Leptomitus lacteus (Roth), Agardh. (Figs. 21, 22). Hyphæ delicate, constricted at intervals, the largest rarely exceeding 40μ in diameter at the base, decreasing in successive segments rarely branching elsewhere than at the distal ends of the segments. Cellulin grains conspicuous about 10μ in diameter

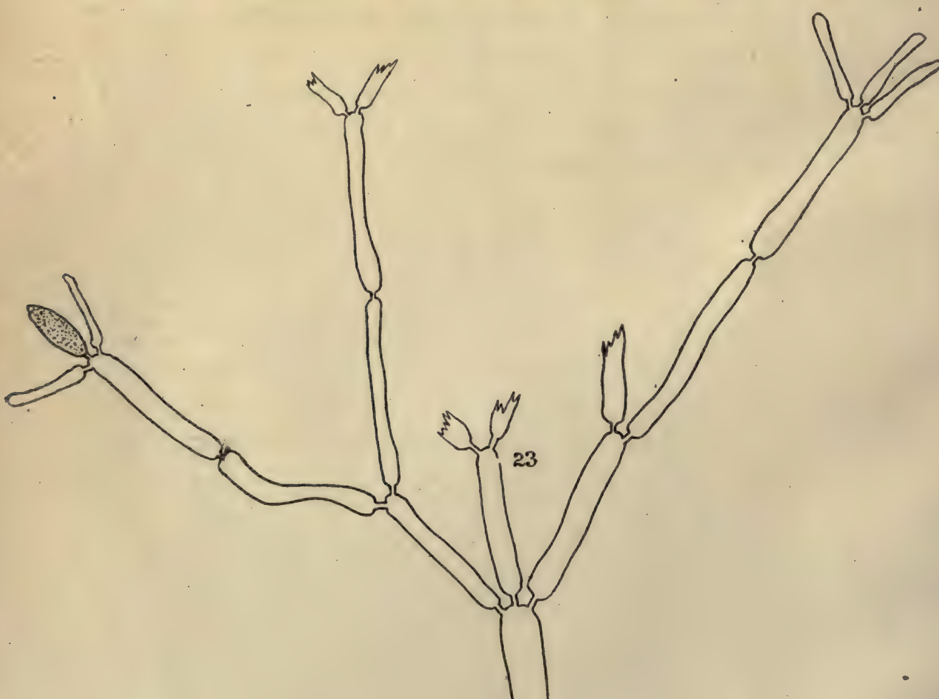


and frequently forming a plug at the constrictions between successive segments. Sporangia formed from slightly swollen segments, often in series. Zoospores in a single row averaging about 13μ in diameter, sometimes encysting within the sporangium, but generally escaping and swarming separately Except in terminal sporangia the escape papilla is lateral.

This species was of frequent occurence in the cultures made appearing first in December, 1907, in a culture made from tap water of the Sydney water supply. Grown on dead flies it forms a thick, white, felted covering over the substratum.

Genus **Sapromyces** Fritsch.

Sapromyces Sp. (Figs 23 and 24). A form belonging to this genus appeared in a culture made from material collected



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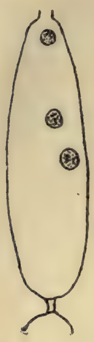
at the upper extremity of Gilholme's Lower Lake, about four miles from the city of Sydney and south of the Cow Bay Road.



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The observations of it were very incomplete. The branched hyphæ attained a maximum length of about $2^{mm.}$ in the culture, but might possibly have grown longer as it early became overrun with bacteria, and it was found impossible to maintain it. The sporangia were elongated egg-shaped and averaged about $30\mu \times 90\mu$. The encysted zoospores were about 10μ in diameter. These were not observed in the act of swarming, but empty sporangia were common and in some, as in the one figured (Fig. 24), a few zoospores had evidently failed to escape and had encysted within the sporangium. Two or three sporangia may be found formed at the extremity of a segment. No structures were observed in this form corresponding to the conceptacula of Reinsch[7], and which are unhesitatingly referred by Dr. Thaxter to the work of chytridiaceous parasites attacking the sporangia[8].

CONSPECTUS OF CLASSIFICATION.

(GROUP)		(FAMILY)	(GENUS)	(SPECIES)
SAPROLEGNIINEÆ	A	1. SAPROLEGNIACEÆ	1. SAPROLEGNIA	1. *S. monoica.*
				2. *S. diclina.*
			2. ACHLYA	3. *A. americana.*
				4 *A deBaryana.*
				5. *A. polyandra.*
				6. *A. apiculata.*
				7. *A. racemosa.*
				8. *A. racemosa* var. *stelligera.*
				9 *A. acadiensis.*
			3. APHANOMYCES	10. *A. stellatus.*
		2. LEPTOMITACEÆ	4. LEPTOMITUS	11. *L. lacteus.*
			5. SAPROMYCES	12. *S (sp.)*
	B	3. PYTHIACEÆ		

REFERENCES.

(1) Botanical Gazette, vol. 45, p. 194.

(2) Bulletin of the U. S. Fish Commission for 1893, p. 163.

(3) "Observations on the Biology and Cytology of a new variety of *Achlya americana*," Annals of Botany, vol. 13, no. 49.

(4) "Zur Entwickelungsgeschichte und Systematik der *Saprolegnieen*," München, 1894.

(5) "On two new species of *Saprolegnieæ*." Journal of Microscopical Science 1867, p. 121.

(6) "The *Saprolegniaceæ* of the United States with notes on the other species." Trans. Am. Philos. Soc., 17: 63-148, 1892.

(7) "Beobacht. über einige neue *Saprolegniaceen*." Jahr. f. Wissensch. Bot., bd. xi, 1878.

(8) The genus *Nægelia* of Reinsch. Bot. Gaz., vol. 19, p. 49-55.

Explanations of Figures.

(The numbers in brackets give the approximate linear magnification.)

Saprolegnia monoica Pringsh. Figs. 1-2.

1. (100) Empty sporangia.
2. (225) Oogonium.

Saprolegnia diclina Humph., Fig. 3.

3. (225) Oogonium with attached antheridia. The connection of these with their filaments of origin is readily severed.

Achlya americana Hump., Fig. 4.

4. (225) Oogonium with antheridial branch and antheridia.

Achlya deBaryana Humph. = *A. polyandra* deBary, Figs. 5-8.

5. (225) Empty sporangium, young culture.
6. (100) Two filaments with oogonia and antheridial branch. The production of an oogonium at the base of an antheridial branch as here figured is very rare. (*b*) A ripe eccentric oospore.
7. (225) Oogonium with young oospores and antheridia.
8. (225) Oogonium with much coiled antheridial branch.

Achlya polyandra Hildeb., Fig. 9.

9. (225) Typical oogonium with antheridial branches and antheridia. The antheridial branches in this case take their origin in part from the oogonial branch and in part from other filaments.

Achlya apiculata deBary, Figs. 10-13.

10. (50) Empty sporangia from vigorous culture.
11. (225) Oogonium with antheridial branch and antheridia. No apiculus on oogonium.
12. (225) Typical oogonium—antheridia omitted.
13. (225) A rare intercalary oogonium.

Achlya racemosa Hildeb., Fig. 14.

14. (225) Oogonium with antheridia.

Achlya racemosa var. *stelligera* Cornu., Fig. 15.

15. (225) Oogonium with antheridia.

Achlya acadiensis sp. nov., Figs. 16-19.

16. (100) Sporangium with encysted zoospores.
17. (225) An intercalary oogonium.
18. (225) Terminal oogonium.
19. (225) A portion of the wall of an oogonium.

Aphanomyces stellatus deBary, Fig. 20.

20. (225) Oogonium with oospore.

Leptomitus lacteus Agardh. Figs. 21 and 22.

21. (225) A portion of a hypha shewing method of branching and cellulin granules.
22. (225) A terminal sporangium with zoospores encysted within it.

Sapromyces sp. Figs. 23 and 24.

23. (100) Hyphæ shewing method of branching and formation of sporangia.
24. (225) Empty sporangium with three encysted zoospores.

On the Occurrence of Tin in Nova Scotia.—By Harry Piers, Curator of the Provincial Museum, Halifax.

Read 18th May, 1908.

In the following notes I desire to place on record such particulars as are known regarding the recent interesting discovery of tin ore *in situ* in Nova Scotia.

Tin supply and demand.—New sources of tin ore are being eagerly looked for throughout the world, and every new find immediately attracts attention; for when we consider the large and yearly increasing consumption of tin, and the limited sources of supply, we readily see that the supply is now not equal to the demand, and new deposits must be looked for. During the year 1907 the average price of tin in New York was about 38 cents per pound. In 1903 the average price was 28 cents. With the exception of the Cornish mines, nearly all the world's production of tin is obtained from alluvial deposits and not from vein formations. Over half of the world's production comes from the alluvial deposits of the Malay States. Owing to the high price of the metal, it is possible to work very low-grade ores, if in quantity. If a vein contain but one per cent. of metallic tin, with the metal at 38 cents a pound, it would make an ore worth $7.60 a ton, and should be a profitable proposition if the deposit was of sufficient size.

In North America tin has been found in Maine, New Hampshire, Massachusetts, North and South Carolina, Virginia, Alabama, South Dakota, Texas, California, Alaska, Mexico, and in the Yukon in Canada, and it has been detected by analysis in small quantities elsewhere. In the United States, with the exception perhaps of Alaska, the deposits found in North and South Carolina are the only ones lately discovered

that have offered any chance of becoming commercial producers of tin. In Carolina the ore mostly occurs in pegmatite dikes, etc., in a wide area of schist (probably of Cambrian age), bordered by granite on one side and gneiss (probably Archæan) on the other.*

Previous occurrences in Nova Scotia.—In tracing the reported finds of tin in Nova Scotia, we learn that some time previous to 1869, W. Barnes is said to have discovered tin in a granitic sand, composed of grains of quartz and feldspar, at Tangier, Halifax county; and John Campbell is said to have found it at Shelburne.† Dr. E. Gilpin also obtained it in panning gold at Tangier. It has likewise been reported from Country harbor, Guysborough county.‡ I have also been informed on good authority (Dr. E. Gilpin) that it was found in a granite boulder near Rawdon, Hants county. All of these finds were in connection with drift material derived from granite areas, none of which was traced to its original source.

I may say that since the discovery at Lake Ramsay, now to be described, tin has been reported to me as found in small quantity and determined by test at two other localities in Nova Scotia, but at present I am not at liberty to give further information thereof.

Tin at Lake Ramsay.—For some years past, two or three persons have been employed in prospecting for tin in Nova Scotia, and from time to time suspected samples have been brought to the Provincial Museum, which mostly proved to be sphalerite or zinc-blend, or tourmaline. One of these prospectors who has been longest in the field, is Charles Keddy, of Lake Ramsay, to whom further reference will soon be made.

During the summer of 1906, pieces of quartz crystal were discovered on the surface of John Reeves's land, in woodland a few hundred yards south-westward of his house, and about

* Piatt (J. H.) and Sterrett (D. B.). Tin deposits of the Carolinas. N. Carolina Geol. Sur., Bul. 19 (1904).

† How (H.). Mineralogy of N. S., 1869, p. 78.

‡ Gilpin (E.). Minerals of N. S., 1901, p. 60.

$\frac{3}{8}$th of a mile south of the Dalhousie road, and about $\frac{7}{8}$th of a mile south-south-west of the southern extremity of Lake Ramsay, to the west of New Ross, 16 miles inland from Chester Basin, Lunenburg county, N. S. With the expectation of finding diamonds, Mr. Reeves and a neighbor, Benjamin Meister, dug a shallow pit where the crystals were observed, and soon were in a deposit of white kaolin in which occurred large crystals of quartz, mostly with a faint smoky tint, and also a little purplish-black fluorite. Specimens of these minerals were first brought to the Provincial Museum on 29th August, 1907, and other samples subsequently.

Charles Keddy, the prospector before-mentioned, examined the material thrown out by Reeves and Meister in the course of their operations, and found a few small pieces of a heavy, dark-colored mineral which he brought to the museum in the middle of October, 1906. This proved to be cassiterite (tin oxide), a mineral which, when pure, contains theoretically 78.6 per cent. of metallic tin. This was the first discovery of tin ore *in situ* in Canada in anything approaching economic quantity, and the first discovery of it *in situ* in Nova Scotia. Mr. A. L. McCallum, assayer of Halifax, produced a button of metallic tin from Keddy's samples. This interesting button is now in the museum. Upon discovering the character of his find, Keddy took up the property on 22nd October, under a license to search, in the names of John Reeves, Benjamin Meister and Charles Keddy of Lake Ramsay, and E. E. Bishop of Halifax. Since then I understand Reeves's and Meister's shares have been transferred. No work was done on the prospect for the rest of the year, owing to the lateness of the season and lack of harmony among those interested.

As the find was one of unusual interest, I was directed by the inspector of mines to make an examination of it, and proceeded to the locality accompanied by M. H. McLeod of the Geological Survey, who wished to obtain samples for that

department. On the way there a snowfall unfortunately occurred which covered all exposures. I visited the deposit on 29th November, and found a small pit, about 12 feet long by 5 feet wide and 10 feet deep. The hole was nearly three-quarters full of water, and this with the mantling of snow, made it impossible to make a satisfactory examination. From what could be seen under these unfavorable conditions, the country-rock was apparently an ordinary grey granite, consisting of quartz, white feldspar and mica. I noted masses of reddish granitic rock, perhaps a half-mile eastward on the Dalhousie road, and it was also reported at Lake Ramsay, but it seemed to have no connection with the deposit at Reeves's. I could not hear of any sedimentary rocks in the neighborhood, the nearest rocks of this kind being about two miles to the north-west towards Wallabach lake. None were associated with the tin deposit.

It was found that the cassiterite occurred in small quantities in either a dike or a schlieren of coarse pegmatite, becoming aplitic in parts, cutting or segregated from the ordinary granite. The pegmatite mass apparently had a nearly vertical attitude, and if the length of the hole indicated the strike of the deposit, as it undoubtedly did, it lay in a north-east and south-westerly direction. How far the pegmatite extended in either direction horizontally, or how it changed in character in those directions could not be ascertained, and I recommended that the surface be stripped at intervals on the strike that this might be ascertained if possible, in preference to continuing to sink for the present in the pit.

The feldspar in the upper parts of the deposit had decomposed to kaolinite, some portions of which were of fair quality and colour. In the deeper part of the pit the rock was becoming less altered. In the kaolin and unaltered feldspar were numerous immense crystals of quartz, of a slightly smoky tint, unfortunately not sufficiently transparent to make them of com-

mercial value. The largest of these crystals, which is now in the museum, with two others nearly as large, measures 27 inches in length by 10 inches in thickness. These are by far the largest quartz crystals ever found in Nova Scotia, and they bear favorable comparison with large crystals found elsewhere in America.

Mica was not as abundant as I had expected, as I supposed it might have been segregated into large masses commensurate with the size of the quartz and feldspar crystals. Such possibly may yet be found to be the case in another part of the deposit. Most of the mica, especially in the more aplitic parts, is a lithia mica, probably lepidolite, sometimes with a delicate lilac-pink tint.

The cassiterite occurred in small quantities in the kaolinite, as far as shown by the material then taken out, although it was hoped that elsewhere in the deposit it might be found more largely segregated. It could not be ascertained if the ore occurred specially in any particular part of the deposit or in a pay-shoot.

Associated with the pegmatite and kaolinite were also purplish-black fluorite, amblygonite of a beautiful light blue color (the first time this mineral has been discovered in Canada), black tourmaline, wolfram, tungstite, scheelite, molybdenite, etc.

Subsequent to my visit another dike or vein carrying tin was reported to have been found near the main road, not far from the first locality.

From samples brought to the museum, I find that some of the grey and reddish granites near Lake Ramsay carry small amounts of chalcopyrite or pyrite; and small vugs in some of the reddish granitic rocks contain deposits of purple fluorite as well as the sulphides. Slender crystals of transparent tourmaline with a dark outer shell occur in a hematite-coated quartz boulder from the shore of Lake Ramsay. Ordinary

black tourmaline occurs in the granite of the district. Sphalerite has also been brought to me from the district, as well as a small gold specimen in quartz said to occur in the granite of Lake Ramsay. About one and a half miles eastward of the tin deposit, is an interesting occurrence of molybdenite in a dike or vein in granite on Larder river. At Wallabach lake, to the north-west, is a well-known deposit of manganese ore in a fissure in granite, which has been rather extensively mined in the past.

A report on the discovery of tin at Lake Ramsay was made in the Museum Report for 1906, and the find immediately attracted attention, and enquiries regarding the deposit were received from the United States and elsewhere.

In May, 1907, Mr. W. F. Ferrier, formerly a member of the staff of the Geological Survey of Canada, visited the locality in company with Mr. A. A. Hayward, president of the Mining Society of Nova Scotia, and brought away samples which are now at the museum. Work at sinking was then in progress under charge of Neil A. King, who had acquired an interest therein. In June, July and September, Mr. McIntosh of the Geological Survey visited the deposit to watch developments, and in August Mr. E. R. Faribault examined it, the hole then being 18 feet deep, 12 feet long and 10 feet wide; and in October and November Mr. R. A. A. Johnston of the survey was there, on the last occasion accompanied by Dr. G. A. Young of the department, who has special knowledge of igneous rocks. The pit was then about 20 feet deep.

Mr. Faribault reported on the deposit in the *Summary Report of the Geological Survey* for 1907, pp. 80-83,* and Dr. Young in the same report, p. 77.† The former states that there is no well-defined foot- or hanging-wall. The strike, he says, is N. 65° E. and the dip is to the north-west at an angle vary-

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* Faribault (E. R.). New Ross tin deposits. Sum. Rept. Geol. Surv. Canada, 1907, pp. 80-83.

† Young (G. A.). The tin-bearing locality at New Ross, N. S. Sum. Rept. Geol. Surv. Canada, 1907, p. 77.

ing from 75° at the surface to 60° at the bottom of the pit. The outcrop is about 8 feet wide and 12 feet long, but at one end at least it extends farther to the north-east under a cap of granite. The deposit, he continues, appears to be what is often called by miners a 'blow-out,' and is probably the result of deep solfataric action, and it should extend to a great depth. He considered that the results so far should be considered very satisfactory and warrant much greater development.

I had hoped that additional surface work might prove that the pegmatitic cassiterite-bearing rock extended to some distance, as is the case in most dikes, but Dr. Young reports that at the time of his visit a certain amount of stripping in the immediate neighborhood had failed to disclose further outcrops of the tin-bearing body, which seems to be of the nature of an irregular, acid schlieren, closely connected in origin with the containing muscovite granite. He says the light-colored muscovite granite with which the cassiterite-bearing pegmatite is associated, was seen at a number of points in the neighborhood and appears to be cutting a coarser-grained biotite granite.*

Much activity followed the discovery of tin-ore at this place, and several pegmatite dikes, etc., near New Ross were located and prospected. The Geological Survey found traces of tin in small specimens from a pegmatite dike, 24 feet wide, a mile north of Nevertell lake, six miles south of Reeves's place. Bismuthinite and molybdenite were discovered in a silicious and aplitic dike or vein, one mile south of New Ross corner; and tungston ores and rare earths were found in a dike of pegmatite, 20 feet wide, one mile east of New Ross Corner, on land taken up, on a license to prospect, by Dr. Lavers and Frank Boylen of New Ross.

Associated minerals.—As a result of the examination made at the survey's laboratory, by Mr. R. A. A. Johnston, of material from all the deposits in the granites of the vicinity of

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* Young (G. A.). *Loc. cit.*

Lake Ramsay and New Ross, the following unusually long list of minerals have been detected in varying quantities:—Cassiterite, monazite, one of the columbite minerals, durangite, amblygonite, a lithium mica (probably lepidolite), wolframite, scheelite, hübnerite, molybdenite, sphalerite, beryl, apatite, tourmaline, fluorite, pyrolusite, manganite, limonite, hematite, magnetite, siderite, bismuthinite, argentiferous galenite, chalcopyrite, pyrite, arsenopyrite, kaolin, and crystals of light and dark smoky quartz.* Some of these are rare minerals which have a use in the arts and command a large price. Amblygonite and durangite are new to Canada.

Concentration test.—On 6th August, 1907, a sample of the material from the deposit at Reeves's pit at Lake Ramsay, consisting of 14 bags, each weighing about 300 lbs., was received by Professor Frederic H. Sexton, director of technical education, Halifax, from Neil A. King, in order that a test thereof might be made. This lot of ore was stated to have been taken directly across the deposit (about 12 feet wide), from wall to wall, at a depth of 18 feet, and represented the average ore that could be extracted from the pit at that depth. The lot was just as it had been taken from the pit, except that the large crystals of quartz had been picked out, and it was said that about one-fifth to one-sixth of the bulk of the ore in quartz crystals had thus been removed by hand-picking. Professor Sexton reports that the ore consisted for the greater part of transparent vitreous quartz, quartz crystals, a soft friable lustrous greenish feldspar, and soft kaolin from the decomposition of the feldspar by weathering agencies. Some lumps were stained a dark red, indicating the weathering of pyrites, and Mr. King said that such material contained the most tin. Muscovite in small crystals was sparsely distributed throughout the ore. Sprinkled through the ore were small dark crystals of tourmaline and almost black fluorite. Cassiterite was not identified in any of

* Faribault (E. R.). *Loc. cit.*

the lumps inspected. Some of the fluorite occurred in dendritic form.

A sample of five bags was selected for treatment, whose combined net weight was 1403.94 pounds (637 kilos). The results of the concentration and assays are thus summarized by Professor Sexton, in his report dated 4th September, 1907:

(*a*) The original ore as sampled and assayed contained only a trace of tin.

(*b*) 543.2 pounds of product through 4 on 8 mesh were treated on a Collom jig with no resulting concentration whatever. An assay of the material fed showed a trace of tin.

(*c*) 310.8 pounds of product through 8 on 16 mesh were treated on a Collom jig and only a very thin layer of about $\frac{3}{8}$th inch on the first sieve showed signs of being concentrated material. This layer when separated by skimming was found to consist mostly of included grains of quartz and feldspar, with fluorite and tourmaline, and when this product was assayed it was found to contain tin, but in such small quantity that it could not be weighed.

(*d*) 257.3 pounds of product through 16 mesh sieve was treated on a half-size Wilfley table, making a small amount of impure heads containing 0.583 per cent. of tin, a very small amount of very impure tailings containing 0.08 per cent. of tin, and about 237.81 pounds (107.9 kilos) of clean tailings containing no tin at all. A calculation of the tin in the whole product fed to the Wilfley table showed it to contain 0.0192 per cent., a very small amount indeed.

Professor Sexton concludes that the percentage of tin present in the ore supplied to him is so small as to make the working of such ore as a whole unprofitable; and he thinks that the cassiterite must exist in the form of minute flakes and crystals in the ore, and in small quantity. He recommends the locating, by careful inspection and assays, of some ore-shoot which contains enough tin to make practical mining profitable, for it will

evidently not pay to mine the whole width of the pegmatite material (12 feet) because of its paucity of tin.

This proper method of concentration of this tin ore is direct graded crushing and concentration on a fine sand concentrator such as a jerking table like the Wilfley pattern.*

Conclusions.—Professor Sexton's test indicates that the whole width of the dike, at that depth, is low in tin contents, and an effort should be made to discover if the cassiterite is segregated in any one part of the dike, as is quite likely, in which case the percentage would be increased in the portion of the dike that might be mined. Numerous pieces of ore, about the size of a hazel-nut, have been obtained and are in the Provincial Museum, but it is not known from what part of the deposit they were taken. The presence of an ore-shoot should be ascertained if possible. It must be remembered that some of the associated minerals are valuable for various purposes, and bring excellent prices in the market, and if some of them are proved to be in sufficient quantity might be even more profitable than the tin, or at any rate might be worked conjointly with that ore, and so make a profitable proposition. So far these associated minerals do not seem to have attracted the attention of the owners, although they much merit consideration.

I would suggest that the gravels and sands of the low-lying districts about New Ross and other favorable localities on or adjoining the granitic areas of Nova Scotia be carefully examined for the occurrence of stream tin, as such alluvial deposits might be found to be more valuable than those *in situ*. Pegmatite dikes in granite and in the adjacent sedimentary metromorphis rocks of the gold-measures, particularly such dikes as contain boron and fluorine minerals, such as tourmaline, fluorite, etc., and also lithium-bearing minerals, should be

* Sexton (F. H.) Report on concentration test on tin ore from New Ross. 4th Sept., 1907. Manuscript.

closely examined.* In the neighborhood of New Ross, the vicinity of the sedimentary rocks, adjoining the granite, towards Wallabach lake, might well be prospected.†

It may be noted that sphalerite and tourmaline are sometimes mistaken for cassitrite, as I have found the case in Nova Scotia, but the unusual weight and hardness of the latter will probably be the readiest way for the prospector to roughly distinguish the mineral in the field. At Lake Ramsay the prospectors have often mistaken wolframite for tin ore. Cassiterite may be determined by the blow-pipe, by taking a small quantity of the mineral, very finely powdered, thoroughly mixing it with six or eight times its volume of sodium carbonate (baking soda) and a little powdered charcoal, and fusing this mixture on charcoal before the blow-pipe with the reducing flame, when a button of metallic tin will result.

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* Prospectors might well examine, for traces of tin, the reported chalcopyrite-bearing granite of the Alton road which leads north from the Dalhousie road.

†On 24th June, 1908, there was received at the Provincial Museum from Dr. Henry W. Cain, a specimen of cassiterite with chalcopyrite, pyrite and sphalerite from a vein-like deposit in granite on the north-west side of Wallabach stream, (a branch of Gold river,) about half way between Camp and Harris Lakes, and nearly 1 mile south-west of south end of Wallabach Lake, on farm of Henry Meister, 3½ miles north of New Ross, Lunenburg Co. It was reported that the deposit had been found late in the summer of 1907, by Ernest Turner of Mill Road, New Ross, and the rights are now held by Mr. Turner, Mr. Meister, and Dr. Cain. Other specimens brought in later contained a little epidote and talc. Ore from this deposit assayed by A. L. McCallum of Halifax, gave the following result: silica ($Si\ O_2$), 2.50%; cassiterite ($Sn\ O_2$), 47.00%; chalcopyrite ($Cu\ Fe\ S_2$), 38.00%; Zinc (Zn), 12.25%. This ore differs in character from that at Reeves's.

SCHEELITE IN NOVA SCOTIA.—BY A. L. McCALLUM, B. SC., Halifax.

Read 14th December, 1908.

The deposit under consideration is situated at the western boundary of the Moose River gold district, Halifax county, being about 1½ miles west of the old Torquay crusher.

The first discovery made was a boulder containing a fairly large amount of tungstite. Up to the present no more of this tungstite has been found, but always unaltered scheelite.

The first scheelite drift was found in the bed of a small brook which runs through the property. Scheelite drift was found quite plentifully in this brook up to a point beyond which at that time we were not able to find more. At this point a cut was made in the bank with the result that the first scheelite vein was found. A small trial pit was sunk at this place and another one a little further east on the same vein.

The formation shown by this work was as follows: Very sharply defined "whin" (quartzite) walls with a three foot slate belt between, dipping at an angle of about 75° N. The vein is on the footwall and consists of a series of lenses of varying sizes. The vein-matter is composed of scheelite, quartz and a little mispickel (arsenopyrite). The vein-matter is very irregular in composition, varying from pure scheelite to pure quartz or pure mispickel, and all combinations of these three.

Subsequently drift was found north of this vein, and eventually three veins were found about fifty feet north. To the south of this first vein, ten veins in all have been opened up. Several of these at the points opened up are too low-grade to be of any value. The rest are all fairly high grade. On account of the great variations in the composition of the vein-matter, it is difficult to form an opinion of the average contents of the veins taken as a whole; but leaving out those that are too low-

grade, the remainder will probably average between 30 and 50 per cent. scheelite.

So far, prospecting has been confined to a belt 200 feet wide north and south, and a distance about 1200 feet east and west. The total width of vein-matter in the 200 feet would be about 50 inches.

Wolframite has been known for centuries to German and Cornish tin miners. It was found by experience that when smelted with tin in the furnace it impeded the reduction of the tin and facilitated its scorification, so it was thought it ate up the tin, as the wolf eats the sheep. Hence the derivation of the word wolfram.

In Cornwall the miners termed it "call" or mock-lead on account of its great weight, thinking it contained lead. But the Swedish chemist, Scheele, proved in 1781 that this mineral, as well as another which he had called tungsten, contained a specific mineral acid now called tungstic acid, and that wolframite is essentially a tungstate of iron, and tungsten now called scheelite, is tungstate of lime.

These minerals were employed in 1840 by the English chemist Robert Oxland for the preparation of tungstate of soda to be used as a mordant in dyeing cloth, and as proposed by Versmann and Lyon Playfair, for the impregnation of vegetable tissues, linen and cotton, to render them non-inflammable and almost fire-proof.

Its greatest use is as an alloy with steel. Tungsten steel was first made in 1855 in Austria, and was introduced to the trade later by Musket, an Englishman. It makes armor plate very tough and difficult to fracture and split. In projectiles and high speed tools it forms an alloy which retains its temper at a red heat. It makes car springs stiffer. It increases the permanency of magnets and makes a more powerful response in sounding plates and wires for musical instruments.

It is commonly stated that it will take the place of carbon in producing hardness, but this is not true. It is more correct

to say that it will assist carbon in producing hardness and therefore high tungsten steels may have a lower carbon.

No amount of tungsten or any other element will make steel hard in the absence of carbon or even when the carbon is low. The tungsten produces hardness by its effect on the condition of the carbon; that is, by helping to retain the carbon in its solid solution and not by any effect of its own. It is for this reason that a lesser amount of carbon will produce hardness in the presence of tungsten or other similar element.

A variety of bronze-powder is made by fusing potassium, tungstate and tin. It is also used for coloring glass and as a glaze for porcelain. Recently metallic tungsten is being used extensively in the manufacture of incandescent electric lamps. It is claimed that it uses only one-third the amount of current required by a carbon lamp, and that it maintains its rated candle power for 1,000 hours.

Some Effects of Ice Action near Grand Lake, Cape Breton.—By W. S. Brodie, B. A.

Read 24th April, 1909.

In the vicinity of Grand lake, about four miles from Sydney, as also near other lakes within a radius of fifteen miles from that spot, may be noticed some curious formations.

Roughly parallelling the shores of Grand, Waterford and Sand lakes are found mounds of considerable extent. These mounds vary in length, height, and width, running through swamp, forest and open ground. Sometimes they leave the lake shore distant hundreds of yards, at other places sloping to the water's edge. To consider the nature and origin of these mounds is the object of this paper. I will refer particularly to that at Grand Lake as being a type of all.

Size.—In length, I have traced this one in a fairly continuous line, though with frequent breaks, for over a mile.

Height.—Five or six feet above present lake level is their limit. Above the ground at base, the extreme height is about 4½ feet. The elevation of crest seems to bear no uniform ratio to distance from present shore line. I had no means of taking levels along the summit, but judging by the eye it is nearly level. There is at least no decided slope in either direction.

Width.—Where the mound is most pronounced, I found its base to measure about 15 feet in cross-section, its top about six. Allowing a height of five feet, this gives a side slope of 1 in 1.3. Generally, the slope is much less decided. I would judge that when first deposited the slope was sharp. Weathering, erosion, and plant growth has evidently flattened it to a large degree. I could not determine whether the side slopes differed in any uniform way on the same mound. Sometimes one side, some-

times the other was steeper, but for the most part they are almost as much alike as the two sides of a railway fill.

Structure —Physically the material is of all sizes and shapes from sand grains to boulders three and four feet in diameter. As a rule it is gravelly, containing more stones than the surrounding soil. There is no stratification, nor very marked assortment of material.

Mineralogically, the materials do not differ from those of the adjacent soil. All the stones show a weathered surface. Many are somewhat rounded, but this appears to be the result of weathering rather than of water action. I found no facetted surfaces, nor were there any glacial striæ; the stones, however, were not of sufficiently close texture to receive or retain such markings. A good deal of the soil in the mound seems to have resulted from the decay of boulders "in situ."

Age.—On the mound are trees growing many feet in height. One, which had recently been cut down, measured fifteen inches across the butt, 2½ feet from the ground. The roots of this tree, as of many others, spread out immediately at or below the surface, indicating that it had grown on the mound after it had been heaped up. This would show the deposit to be at least as old as the tree. For a birch to grow to that size on sterile soil and in a severe climate, would require 60 or 70 years at least, probably more.

From the weathering of the rocks contained, I would infer a much greater age for the mound than that.

Origin.—By the neighboring country folk, to whom these mounds offer convenient, if somewhat erratic foot-paths, their formation is readily explained. To the industrious beaver of bygone days is given the credit of building these extensive ramparts.

But the beaver, I believe, usually selects a spot on a stream flowing through a narrow gap, to make his work as light as possible in proportion to the increase of depth in water thus secured. These mounds, however, sometimes run through

nearly level country, and occasionally along hillsides, where, had they been absent, the hill itself would have served as a dam. Further, I have found no sticks of timber in any diggings or cuttings that I have examined.

Mounds somewhat resembling these are ascribed to glacial formation. Streams flowing beneath the ice of modern glaciers are loaded to the limit of carrying capacity with morainic material. This is deposited at the bottom of the ice tunnel, and on the final recession of the glacier there is left a sinuous heap of clay, gravel and boulders, to which the name of *esker* is given. Such mounds found throughout Canada and the northern United States are considered to be the work of Pleistocene ice.

But the sub-glacial stream seeking a lower level would scarcely bend upon itself in such fashion as shown in the accompanying blue print.

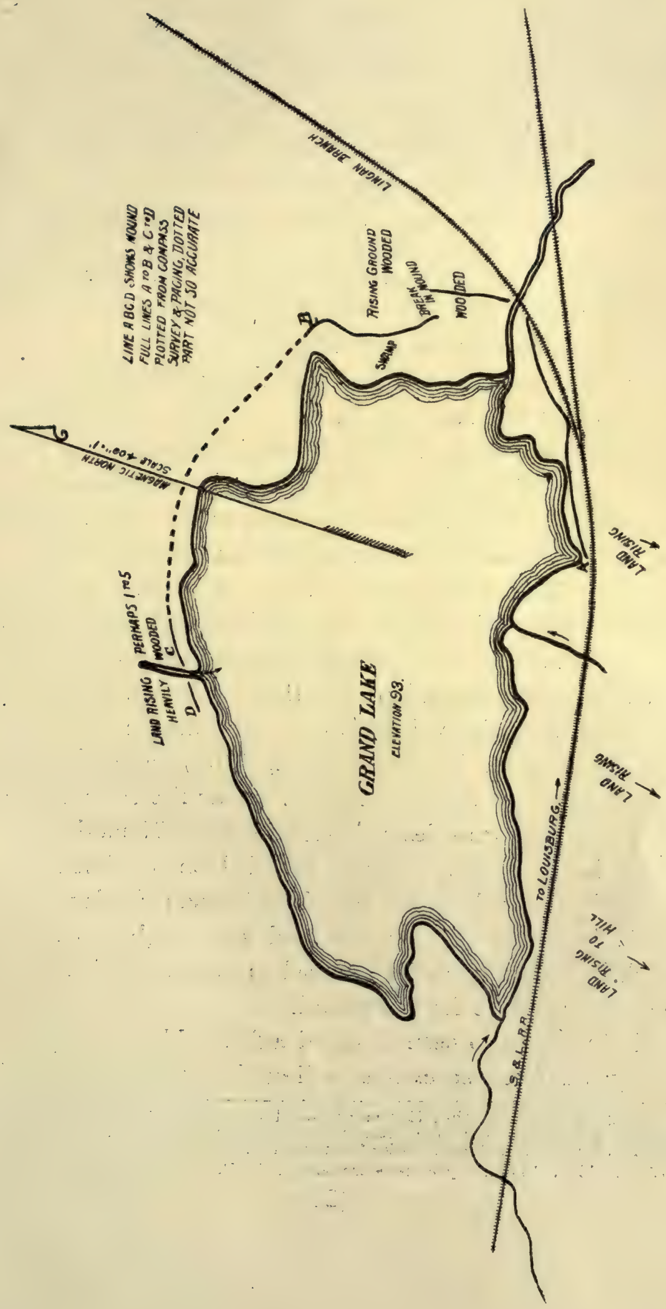
Further, in such a long stream it would surely enlarge its cavern at some points, say where it was obstructed by large boulders, and there spread its load in wide heaps. Although the mounds at Grand lake ramify for short distances, there are no such widenings as might be expected as above. Again the uniformity in height argues against the esker theory.

At the present margin of the lake there are narrow gravel beaches. On one occasion in midwinter, after a thaw of a few days' duration followed by sharp frost, I noticed that the ice in tne lake had pushed against this frozen mass of pebbles. The surface layer, cemented by frost, had buckled under the ice pressure in the form of a ridge, a few inches in height. I have a small photo attached showing this. The question arises, could the large mounds have been formed by the same agency as these small ones? I made several visits to the lake to observe any upbuilding comparable with the mounds in question. I could not find any effects of modern ice shove at all approaching in size the mound under discussion.

Salisbury, in his *Glacial Geology of New Jersey*, p. 98, makes mention of Endmoränes or Geschiebewalls. They have originated through marginal masses of ice becoming separated from the main body during a retreat, probably the final one, of the ice. Here we have a debris loaded iceberg melting where it stands and showering down around it gravel and boulders. These, heaped up in a ridge more or less circular in form, serve as a retaining wall for the water of the lake left at the final melting of the ice.

Or if this ice mass, instead of being entirely separated from the main body, projected as a lobe, we would again have conditions to form such a wall. If the lobe kept melting back as fast as it was pushed forward, its load would be discharged in a continuous line along a stationary front. Naturally where the lobe united with the main body of the ice, we would expect to find the wall missing.

I greatly regret that I was compelled to leave my investigations before completing the survey of the upper end of the lake, from which direction the glacial movement took place.


LINE A B C D SHOWS MOUND
FULL LINES A TO B & C TO D
PLOTTED FROM COMPASS
SURVEY & PACING, DOTTED
PART NOT SO ACCURATE
LINGAN BRANCH
RISING GROUND
WOODED
BREAK IN MOUND
WOODED
SWAMP
MAGNETIC NORTH
B
C
D
PERHAPS 1 TO 5
WOODED
LAND RISING
HEAVILY
GRAND LAKE
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LAND
RISING
TO LOUISBURG
LAND
RISING
TO
HILL
S. & L. R.R.

Catalogue of Butterflies and Moths, mostly collected in the Neighborhood of Halifax and Digby, Nova Scotia.—By Joseph Perrin, MacNab's Island, Halifax, and John Russell, Digby, N. S.

Read 15th February, 1909.

In preparing this list no trouble has been spared to make it as accurate as possible. Errors possibly exist in it, but in the main we feel that it is correct.

All specimens that could not easily be determined, were submitted to the late Dr. James Fletcher, entomologist and botanist of the Central Experimental Farm, Ottawa, who in turn sent the rarer or more difficult specimens to other specialists, such as Dr Harrison G. Dyar, custodian of lepidoptera, U. S. National Museum, Washington, D. C.; Dr. J. B. Smith of New Brunswick, N. J.; Rev. G. W. Taylor of Departure Bay, British Columbia, and others; and we now take this opportunity of thanking these gentlemen for their kindness.

The nomenclature adopted is that of Dr. H. G. Dyar's *List of North American Lepidoptera* ("Bulletin of the U. S. National Museum," No. 52; Wash., 1902), and the numbers prefixed are those used in that list. Our list contains 60 nominal species and varieties of butterflies and 470 moths, total 530.

The list is almost entirely founded on specimens collected recently by the authors, the MacNab's Island (Halifax Harbour)* records being by Mr. Perrin and the Digby ones by Mr. Russell.† Other localities referred to have affixed the name of the one responsible for the record.

There have also been inserted a few additional species, not met by us, from specimens collected near Truro, Colchester

*It may be mentioned that MacNab's Island is situated in the mouth of Halifax Harbour. Fall River, to which reference is occasionally made in the list, is near Waverley, Halifax co., about 16 miles from Halifax.

†A set of Mr. Russell's specimens are now in the Provincial Museum at Halifax.

county, N. S., by Miss Lucy C. Eaton, her collection being now n the Provincial Museum at Halifax, accession no. 2900 (see *Trans. N. S. Inst. Science*, vol. 9, p. xvii), and also some species in the late Andrew Downs's small collection made about Halifax some years ago. These specimens have been personally examined and verified. Other species reported by other writers, but not seen by us, are not as a general rule included. Those interested may, however, consult the following papers:

Belt (Thomas).—List of butterflies observed in the neighborhood of Halifax, Nova Scotia. *Trans. N. S. Inst. Nat. Sc.*, vol. i, pt. 2, pp. 87-92. 1864. [30 nominal species mentioned].

Bethune (Rev. Charles J. S.).—Nova Scotian lepidoptera, with additional notes by J. Matthew Jones. *Ib.*, vol. ii, pt. 3, pp. 78-87. 1879. [79 nominal species mentioned, 7 of which belong to the Rhopalocera (butterflies).]

Jones (J. Matthew).—Review of Nova Scotian diurnal lepidoptera. *Ib.*, vol. iii, pp. 18-27, 100-103. 1871-2. [35 nominal species mentioned.]

Silver (Arthur P.).—List of Nova Scotian butterflies. *Ib.*, vol. vii, pp. 86-88. 1888. [46 nominal species listed, without further data.]

Bethune (Rev. Charles J. S.).—Butterflies of Eastern Provinces of Canada. *25th Annual Rept. of Entomological Soc. of Ontario*, 1894, pp. 29-44. [Sessional papers of Ontario, 1895, No. 18.]

Eaton (Miss Lucy C.).—The butterflies of Truro, N. S.; with remarks, by H. Piers, regarding a few of the species mentioned. *Trans, N. S. Inst. Sc.*, vol. ix, pp. xvii-xviii (Eaton), xviii-xxi (Piers). 1895. [26 nominal species mentioned in the Eaton list. Collection on which the paper was founded is now in the Provincial Museum.]

Order Lepidoptera.

Rhopalocera (Butterflies).

Superfamily Papilionoidea

Family Papilionidæ.

11a. *Papilio turnus* Linn. Very common in all parts of the province; May 24 to July.

14. *P. thoas* Linn. (*P. cresphontes* Cram.). Lake View (near Windsor Junction), Hx. Co.; about Aug., 1901 One specimen taken by Miss Helen King. This specimen is now in the Provincial Museum, Halifax (access. no. 977). First occurrence in Nova Scotia

Family Pieridæ.

38d. *Pontia napi* var. *oleracea* Har. MacNab's Is., Halifax; scarce. Truro (Miss L. C. Eaton). Was formerly reported common at Halifax by T. Belt and J. M Jones.

40. *P. rapæ* Linn. Very common everywhere; May to Aug.

66. *Eurymus philodice* Godt. Common everywhere; May to Sept.

71. *E. interior* Scud. Fall River, Hx. Co., and Digby; not so common as *E. philodice*; July, Aug.

85. *Eurema euterpe* Ménétries. MacNab's Is., Halifax; Aug. 24, 1904. Digby; Aug., 1904.

Family Nymphalidæ.

99. *Argynnis cybele* Fabr. MacNab's Is.; July 22nd, 1904. Digby; very rare; July 13, 14, 1907.

100. *A. aphrodite* Fabr. MacNab's Is. and Digby; very common; July.

102. *A. atlantis* Edw. MacNab's Is. and Digby; very common; July.

131. *Brenthis myrina* Cram. MacNab's Is. and Digby; very common; June and Aug.

146. *Euphydryas phæton* Drury. Truro; Aug. 1901 (Miss Lucy C. Eaton).

169. *Cinclidia harrisii* Scud. Fall River, Hx. Co.; not common (Perrin). Formerly reported as *Charidryas nycteis* by Miss L. C. Eaton (*Trans. N. S. Inst. Sc.*, vol. ix).

186. *Charidryas ismeria* B. & LeC. Nova Scotia (J. M. Jones). *Vide* Bethune's "Butterflies of Eastern Canada," p. 32.

189. *Pyciodes tharos* Drury. Very common everywhere; June, July and Aug.

205. *Polygonia interrogationis* Fabr. MacNab's Is.; plentiful during some seasons. Digby; very rare.

205a. *P. interrogationis* var. *umbrosa* Lint. MacNab's Is. and Digby; but always rare.

206. *P. comma* Harris. Formerly reported from Halifax by T. Belt and J. M. Jones.

207. *P. satyrus* Edw. Digby; but not at all common; Aug.

207a. *P. satyrus* var. *marsyas* Edw. Digby; not common; Aug.

209. *P. faunus* Edw. MacNab's Is. and Digby; common; late July and Aug.

214. *P. progne* Cram. MacNab's Is. and Digby; common; late July and Aug.

215. *Eugonia j-album* B. & LeC. Fall River, Hx. Co., and Digby; common; Aug.

217. *Euvanessa antiopa* Linn. Very common everywhere; late July and Aug.

218. *Aglais milberti* Godt. Truro; Aug. 1900 (Eaton).

219. *Vanessa atalanta* Linn. MacNab's Is. and Digby; quite common; June, July, Aug.

220. *V. huntera* Fabr. MacNab's Is. and Digby; not common; Aug. and Sept.

221. *V. cardui* Linn. Very common everywhere; Aug.

237. *Basilarchia arthemis* Drury. MacNab's Is. and Digby; not common; July.

237a. *B. arthemis* var. *proserpina* Edw. Digby; rare; July. Halifax (Bethune, "Butterfli s of Eastern Canada," doubtless on authority of J. M. Jones).

239. *B. archippus* Cram (*B. disippe* Godt.). Fall River, Hx Co. (Perrin).

Family AGAPETIDÆ

258. *Cercyonis alope* Fabr. MacNab's Is.; scarce; Digby common; July and Aug.

258c. *C. alope* var. *nephele* Kirby. MacNab's Is. and Digby; very common; July and Aug.

286. *Enodia portlandia* Fabr. Fall River, Hx. Co.; two specimens; July 23, 1905. (Perrin).

288. *Satyrodes canthus* Linn. Truro; July 1901 (Eaton).

Family LYMNADIDÆ.

308. *Anosia plexippus* Linn. MacNab's Is.; plentiful during some seasons; Digby; always rare; July and Aug.

Family LYCÆNIDÆ.

335. *Uranotes melinus* Hüb. Digby; July 20, 1907.

371. *Incisalia augustus* Kirby. Northwest Arm, Hx.; not common; Digby; common; May.

374. *I. irus* Godt. *Irus* has recently been separated into two species (*Canadian Entomologist*, 1907). *irus*, Godt., and *polios*, Cook; and all the specimens taken at Digby come under the description of *polios* (Russell). Cole Harbour, Hx. Co.; scarce (Perrin); May.

374a. *I. irus* var. *arsace* B. & LeC. Digby; May 5 to 22, 1906.

376. *I. henrici* Grote & Rob. Digby; May 24, 1905; May 26, 1908.

378. *I. niphon* Hübn. Northwest Arm, Hx.; rare (Perrin).

383 *Erora læta* Edw. Mt. Beaman (Ben Lomond). Digby; very rare; June 19, 1905; June 7, 1906.

385. *Feniseca tarquinius* Fabr. Fall River, Hx. Co., and Digby; rare; May, Aug., Sept.

398. *Epidemia epixanthe* B. & LeC. MacNab's Is.; July 25, 1909.

399. *Heodes hypophleas* Boisd. Very common in all parts of the province; May, June, Aug.

440a. *Cyaniris ladon* var. *lucia* Kirby. MacNab's Is. and Digby; very common; May and June.

440b. *C. ladon* var. *marginata* Edw. MacNab's Is. and Digby; very common; May and June.

440c. *C. ladon* var. *violacea* Edw. MacNab's Is. and Digby; common; May and June.

440f. *C. ladon* var. *neglecta* Edw. MacNab's Is. and Digby; rare; June.

Family Hesperiidæ.

459. *Amblyscirtes vialis* Edw. Fall River, Hx. Co.; two specimens, June 12, 1906 (Perrin).

463. *A. samoset* Scud. Fall River; not common (Perrin).

469. *Pamphila palæmon* Pal. (*P. mandan* Edw.). Fall River; not common (Perrin).

484. *Atrytone hobomok Har.* Very common everywhere; June and July.

520. *Thymelicus mystic* Scud. MacNab's Is. and Digby; very common; June and July.

523. *T. cernes* B. & LeC. Very common everywhere; June and July.

526. *Polites peckius* Kirby. Very common everywhere; June and July.

617. *Thanaos brizo* B. & LeC. Formerly reported from Hx. by T. Belt and J. M. Jones.

618. *T. icelus* Lint. Fall River and Digby; common; May 31 to July 14.

625. *T. juvenalis* Fab. Fall River; rare (Perrin).

Heterocera (Moths).

Superfamily Sphingoidea.

Family Sphingidæ.

653. *Hemaris diffinis* Boisd. Halifax and Digby; not very common; July.

656. *H. thysbe* Fa. MacNab's Is. and Digby; common; June and July.

657. *Lepisesia flavofasciata* Walk. Digby; May 24, 1906.

670. *Deilephila gallii* Rottem. (*D. intermedia* Kirby). MacNab's Is.; summer of 1900; Digby; common in July.

671. *D. lineata* Fabr. MacNab's Is., 1900.

677. *Pholus vitis* Linn. MacNab's Is.; July 29, 1907.

681. *Ampelophaga chœrilus* Cram. (*Darapsa pholus*). MacNab's Is.; July 17, 1901; June 27, 1906; Digby; very common in June.

700. *Sphinx* (*Hyloicus*) *kalmiæ* S. & A. MacNab's Is. and Digby; quite common; June and July.

703. *S. gordius* Stoll. MacNab's Is. and Digby; not common; June and July.

704. *S luscitiosa* Clem. Digby; quite rare; generally take 3 or 4 specimens each year; July 1 to 30 (Russell). One specimen taken at Dartmouth, N. S., July 10, 1910 (Perrin).

722. *Ceratomia undulosa* Walk. Digby; MacNab's Is.; 28 July, 1908 (Perrin): not common; June and July.

726. *Lapara coniferarum* S. & A. 11 July, 1908; MacNab's Is.

728. *Marumba modesta* Harris. Truro; June 1901 (Eaton); Halifax (Downs).

729. *Smerinthus jamaicensis* Drury (*S. geminatus* Say). Very common at both places; June and July.

730. *S. cerysii* Kirby. Digby; July 9, 1906; June 22, 1905; July 6, 7, 1905; rare.

731. *Paonias excœcatus* S. & A. MacNab's Is. and Digby; not common; July.

732. *P. myops* S. & A. Truro; June 1901 (Eaton). Halifax (Downs).

Superfamily SATURNOIDÆ.

Family SATURNIIDÆ.

739. *Samia cecropia* Linn. Very common everywhere.

747. *Tropæa luna* Linn. Dartmouth, N. S., July 10, 1910. (Perrin). Digby; very rare; June 20, 1905; June, 1908.

748. *Telea polyphemus* Cram. MacNab's Is. and Digby; not so common as *S. cecropia*; June and July.

Family CERATOCAMPIDÆ.

770. *Anisota virginiensis* Drury. MacNab's Is.; July 8, 1907; Jan. 3, 1908.

771. *A. rubicunda* Fabr. MacNab's Is. and Digby; not common; July.

Superfamily BOMBYCOIDÆ.

Family SYNTOMIDÆ.

798. *Ctenucha virginica* Char. Plentiful everywhere; July.

Family LITHOSIIDÆ.

817. *Clemensia albata* Pack. Digby; Aug. 3, 1905; Aug. 9, 16, 1907; Aug. 9, 1908.

Family ARCTIIDÆ.

834. *Eubaphe aurantiaca* Hübn. Digby; July 22, 1906.

834c. *E. aurantiaca* var. *brevicornis* Walk. Digby; generally quite common during late July.

836. *Utetheisa bella* Linn. MacNab's Is. and Digby; rare; Sept.

851. *Estigmene acræa* Drury. MacNab's Is. and Digby; common; late June, July.

856. *Hyphantria textor* Harris. MacNab's Is. and Digby; plentiful.

859. *Isia isabella* S. & A. MacNab's Is. and Digby; quite common; July.

860. *Phragmatobia fuliginosa* Linn. MacNab's Is.; June 21, 1908.

861a. *P. assimilans* var. *franconia* Slossin; Digby; June 6, 1906.

862. *Diacrisia virginica* Fabr. Plentiful in all parts of the Province; July.

872. *Hyphoraia parthenos* Harris. Very rare; MacNab's Is., 1900; Digby, July 3, 1905.

874. *Apantesis virgo* Linn. Very common everywhere; July.

922. *Halisidota maculata* Harris. MacNab's Is. and Digby; quite common; June and July.

923. *H. caryæ* Harris. MacNab's Is.; June 9, 1910. Digby; very common; July.

Family AGARISTIDÆ.

949. *Alypia octomaculata* Fabr. Digby; common; July,

952. *A. langtonii* Couper. MacNab's Is.; July 11, 1907; Digby; July 16-22, 1907.

Family NOCTUIDÆ.

Subfamily NOCTUINÆ.

958. *Panthea portlandia* Grote. MacNab's Is.; June 25, 1907. (Perrin).* Halifax (Downs).

961. *Demas propinquilinea* Grote. MacNab's Is.; 15 June, 1906.

964. *Charadra deridens* Guenée. MacNab's Is.; July 11, 1907; Digby; quite common in June.

968. *Raphia frater* Grote. MacNab's Is.; July 15, 1907.

972. *Apatela americana* Harris. MacNab's Is. and Digby; common; June and July.

975. *A. dactylina* Grote, Digby; June 11, to July 15, 1907.

984. *A. lepusculina* Guenée. Digby; Aug. 9, 1907. MacNab's Is.; June 27, 1908.

988. *A. innotata* Guenée. MacNab's Is. and Digby; common; June and July.

*This specimen was examined by Dr. J. B. Smith of New Brunswick, N. J., who writes regarding it, "I cannot make it the same as *P. acronyctoides*, Walker, as that stands in my collection. If we had a female it might help us out; but as between the males I must place it with *portlandia*, unlikely as it seems." *P. portlandia* occurs in the Pacific States, whereas *P. acronyctoides* is an Atlantic States species.

990. *A. morula* Grote. MacNab's Is.; June 26, 1907; Digby; common; June and July.

991. *A. interrupta* Guenée. MacNab's Is.; Aug. 12, 1907; Digby; June 20, July 1, 1907.

999. *A. radcliffei* Harvey. MacNab's Is.; July 26, 1907; Digby; common; June.

1003. *A. hamamelis* Guenée. Digby; June 20, Aug. 2, 16, 1907.

1004. *A. superans* Guenée. Digby; very common; June.

1006. *A. tritonia* Hübn. MacNab's Is.; July 2, 1905.

1008. *A. funeralis* Grote. MacNab's Is.; June 29, 1907.

1009. *A. fragilis* Guenée. Digby; Aug. 2, 1907: June 23, 1908; MacNab's Is.; rare.

1013. *A. revelata* Smith. MacNab's Is.; July 20, 1906; Digby; June 22, 1906; Aug. 2 to 9, 1907; June 25, 1908.

1014. *A. grisea* Walk. Digby; June 20 to July 14, 1907; June 17 to 23, 1908; scarce.

1026. *A. brumosa* Guenée. MacNab's Is.; June 26, July 2, 1907; Digby; very common; June and July.

1028. *A. retardata* Walk. Digby; June 28, July 14, 1906.

1029. *A. sperata* Grote. Digby; June 17 to 25, 1907; June 8 to 17, 1908.

1030. *A. noctivaga* Grote. Digby; very common; June.

1031. *A. impressa* Walk. MacNab's Is.; May 13, 1906; Digby; very common; July and Aug.

1039. *A. impleta* Walk. MacNab's Is.; rare; Digby; common; June and July.

1041. *A. oblinata* S. & A. MacNab's Is. and Digby; scarce; June.

1046. *Aphareta dentata* Grote. Digby; Aug. 29, 1907; one specimen.

1053. *Harrisimemna trisignata* Walk. Have several times found the larva of this species on lilac about Digby (Russell).

1054. *Microcœlia dipteroides* Guenée. Digby; June, 1907; June 30, 1908; not common.

1054a. *M. dipteroides* var. *obliterata* Grote. MacNab's Is.; July 11, 1907; Digby; June 17, 1907.

1055. *Jaspidia lepidula* Grote. MacNab's Is. and Digby; plentiful; June.

1060. *Diphthera fallax* H. S. MacNab's Is.; Aug 1, 1905; Aug, 9, 1907; Digby; always very common; June 19 to Aug. 11.

1067. *Chytonix palliatricula* Guenée. Digby; very common; June.

1075. *Baileya doubledayi* Guenée. MacNab's Is.; July 17, 1906; Digby; July 7, 1905; very rare.

1078. *Hadenella minuscula* Morrison. Digby; very rare; Aug. 3, 1906; Sept. 11, 19, 1907.

1092. *Balsa malana* Fitch. Digby; June 8, 1908.

1102. *Caradrina multifera* Walk. Digby; July 31, 1906.

1136. *Oligia festivoides* Guenée. Digby; very common; June.

1138. *O. versicolor* Grote. MacNab's Is.; July 5, 1909.

1149. *Hadena bridghami* Grote & Rob. Digby; Aug. 3, 1905; Aug. 7 to 28, 1906; Sept. 9 to 30, 1907.

1153. *H. claudens* Walk. MacNab's Is.; July 26, 1907.

1166. *H. mactata* Guenée. MacNab's Is. and Digby; Sept.

1211. *H. stipata* Morrison. MacNab's Is; Sept. 13, 1909.

1212. *H. passer* Guenée. Digby; July 9, 1906.

1217. *H. remissa* Hübn. MacNab's Is.; not common; Digby; July 9, 1906; Aug. 28, 1907; rare.

1220. *H. vultuosa* Grote. MacNab's Is. and Digby; not common; June and July.

1224. *H. finitima* Guenée. MacNab's Is.; rare; Digby; July 9, 1906.

1227. *H. dubitans* Walk. MacNab's Is. and Digby; very common; Aug.

1230. *H. ducta* Grote. Digby; not common.

1231. *H. impulsa* Guenée. MacNab's Is.; scarce; Digby; June 28, 1907.

1232. *H. devastatrix* Brace. MacNab's Is. and Digby; common; July and Aug.

1235. *H. arctica* Boisd. MacNab's Is. and Digby; common; July and Aug.

1241. *H. verbascoides* Guenée. MacNab's Is. and Digby; scarce; July 1 to Aug.

1250. *H. lignicolor* Guenée. MacNab's Is.; scarce; Digby; July 26, 1906.

——. *H. rorulenta.* MacNab's Is.; July 11, 1905; July 31, 1909. Identified by Dr. James Fletcher.

1268. *Polia medialis* Grote. Digby; Sept. 20, 1906.

1277. *Dryobota illocata* Walk. MacNab's Is. and Digby; very common; Aug. and Sept.

1278. *Hypa xylinoides* Guenée. MacNab's Is. and Digby; June and Aug.

1282. *Feralia jocosa* Guenée. MacNab's Is.; June 21, 1907.

1286. *Momophana comstocki* Grote. MacNab's Is.; June 10, 1909.

1288. *Euplexia lucipara* Linn. Common at MacNab's Is. and Digby; July.

1291. *Actinotia ramosula* Guenée. Digby; common; Aug.

1295. *Pyrophila pyramidoides* Guenée. Digby; scarce; Aug.

1296. *P. tragopoginis* Linn. MacNab's Is.; quite rare; Digby; very common; Aug. 23 to Sept. 12.

1297. *Heliotropha reniformis* Grote. MacNab's Is. and Digby; common; Aug. 8 to 28.

1297a. *H. reniformis* var. *atra* Grote. MacNab's Is.; Aug. 13, 1906. Digby; not common; Aug. 8 to 28.

1341. *Oncocnemis atrifasciata* Morrison. Halifax (Downs).

1370. *Adita chionanthi* S. & A. Digby; Sept. 19, 1907.

1389. *Rhynchagrotis gilvipennis* Grote. MacNab's Is.; rare; Digby; not very common; July 24, to Aug. 10.

1390. *R. rufipectus* Morrison. Digby; July 7, 1906.

1393. *R. anchocelioides* Guenée. Aug 31, 1906.

1393a. *R. anchocelioides* var. *brunneipennis* Grote. Digby; Aug. 28, 1906.

1397. *R. alternata* Grote. Digby; common; Aug.

1415. *Adelphagrotis prasina* Fabr. MacNab's Is. and Digby; very common; Aug. 3 to 17.

1423. *Eueretagrotis perattenta* Grote. MacNab's Is. and Digby; plentiful; July 29 to Aug. 10.

1424. *E. attenta* Grote. Digby; July 31 to Aug. 7.

1426. *Semiophora elimata* Guenée. Digby; very common; Aug. 18 to Sept. 11.

1426 b. *S. elimata* var. *janualis* Grote. MacNab's Is; June 11, 1909. Digby; very common; Aug. 15 to 31.

1429. *S. youngii* Smith. Digby; not common; Aug. 15 to 31, 1907; Aug. 20 to 30, 1907.

1437. *Pachnobia salicarum* Walk. MacNab's Is.; scarce.

1454. *Agrotis ypsilon* Rottemb. MacNab's Is. and Digby; very common; Aug. 10 to Sept. 4.

1462. *Peridroma occulta* Linn. MacNab's Is. and Digby; very common; Aug.

1464. *P. astricta* Morrison. Digby; common; Aug 3 to 14.;

1467. *P. margaritosa* Haworth. Digby; common; Aug.

1467a. *P. margaritosa* var. *saucia* Hübn. MacNab's Is. and Digby; scarce; Aug.

1475. *Noctua smithii* Snellen. MacNab's Is. and Digby; very common; Aug. 1 to 17.

1476. *N. normaniana* Grote. Digby; very common; Aug. 3 to 17.

1478. *N. bicarnea* Guenée. MacNab's Is. and Digby; very common in both places; Aug. 3 to 17.

1481. *N. c-nigrum* Linn. MacNab's Is. and Digby; June 26 to Aug. 20.

1484. *N. phyllophora* Grote. MacNab's Is. and Digby; scarce; Aug. 3 to 17.

85. *N. rubifera* Grote. Digby; very common; Aug. 1 to 25.

1487. *N. rosaria* Grote. Digby ; July 1, 1907 ; one specimen.

1489. *N. fennica* Tauscher. Digby ; Aug. 8, 1905 ; Sept. 3, 1907.

1490. *N. plecta* Linn. MacNab's Is. and Digby ; very common ; July 28 to Aug. 10.

1491. *N. collaris* G. & R. Digby ; scarce ; Aug. 23, 1905 ; Aug. 4, 1906.

1493. *N. haruspica* Grote. MacNab's Is. and Digby ; not common ; July 29 to Aug. 7.

1496. *N. clandestina* Harris. MacNab's Is. and Digby ; July 17, 1905 ; July 27, 1906.

1540a. *Feltia jaculifera* var. *herilis* Grote. MacNab's Is. and Digby ; not common ; Aug. 7 to 22.

1545. *F. venerabilis* Walk. MacNab's Is.; scarce ; Digby ; Sept. 11, 1907.

1549. *F. valubilis* Harvey. Digby ; June 28, 1905.

1552. *Porosagrotis vetusta* Walk. MacNab's Is.; Aug. 28, 1906 ; one specimen.

1556. *P. mimallonis* Grote. Digby ; Sept. 17, 1907.

1603. *Paragrotis velleripennis* Grote. Digby ; Sept. 19, 1907.

1620. *P. scandens* Riley. MacNab's Is.; Aug. 20, 1903.

1649. *P. messoria* Harris. Digby ; quite common ; Aug. 22, to 31.

1707. *P. insulsa* Walk. Digby ; quite common ; Aug. 10 to 28.

1719. *P. ochrogaster* Guenée. MacNab's Is.; scarce ; Digby ; Aug. 10, 12, 1905 ; Aug 22, 1906.

——. *P. bestitura.* MacNab's Is ; Aug. 12, 1909 ; determined by Dr. J. B. Smith.

1737. *P. redimicula* Morrison. Digby ; not common ; July 29 to Aug. 22.

1753. *Anytus privatus* Walk. MacNab's Is.; not common ; Digby ; very common ; Aug. 3 to Sept. 11.

1756. *A. profundus* Smith. Very common at Digby during August.

1762. *Ufeus satyricus* Grote. MacNab's Is.; April 4, 1906.

1773. *Mamestra nimbosa* Guenée. Digby; Aug. 12, 1907.

1774. *M. imbrifera* Guenée. MacNab's Is.; scarce; Digby; common; July 14 to Aug. 3.

1775. *M. purpurissata* Grote. Digby; common; Aug. 3 to 14.

1792. *M. atlantica* Grote. MacNab's Is.; Digby; June 22, 1907.

1793. *M. radix* Walk. Digby, June 17, 1907.

1796. *M. subjuncta* G. & R. Digby; Aug. 17, 20, 1907; June 25, 1908.

1800. *M. grandis* Bois. MacNab's Is; June 6, 1910.

1801. *M. trifolii* Rottemb. MacNab's Is.; Aug. 11, 1907; not common. Digby; June 28, 1905; June 19, 1907.

1803. *M. rosea* Harvey. Digby; July 22, 1905; June 25, 1907.

1806. *M. rubefacta* Morrison. Digby; June 18, 1906.

1807. *M. picta* Harris. MacNab's Is. and Digby; June 21, 1905; June 22, 1906.

1808. *M. cristifera* Walk. MacNab's Is.

1809. *M. assimilis* Morrison. MacNab's Is. and Digby; rare.

1810. *M. latex* Guenée. Digby; July 8, 1907.

1812. *M. adjuncta* Boisd. MacNab's Is.; rare; Digby; July 3, 1906; June 8, 1908.

1822. *M. ligitima* Grote. MacNab's Is. and Digby; June 20, 1907.

1823. *M. lilacina* Harvey. MacNab's Is.; rare.

1829. M. *renigera* Stephens. MacNab's Island and Digby; not common; July 18 to Aug. 22.

1832. *M. olivacea* Morrison. MacNab's Is. and Digby; very common; Aug. 3 to 22.

1842. *M. lorea* Guenée. Digby and MacNab's Is.; common; June 15 to July 14.

1882. *Barathra curialis* Smith. MacNab's Is.; rare; Digby; July 13, 1906.

1885. *Morrisonia sectilis* Guenée. Digby; not common; June.

1885a. *M. sectilis* var. *vomerina* Grote. Digby; common; June.

1950. *Nephelodes minians* Guenée. MacNab's Is.; common; Digby; common; Aug. 15 to Sept. 4.

1953. *Heliophila unipuncta* Haworth. MacNab's Is. and Digby; common; Aug. 14 to Sept. 5.

1954. *H. pseudargyria* Guenée. Digby; July 17, 1907; June 17, 1908.

1957. *H. luteopallens* Smith. MacNab's Is. and Digby; very common; June 20 to Aug. 2.

1975. *H. insueta* Guenée. MacNab's Is.; Sept. 7, 1907.

1979. *H. commoides* Guenée. MacNab's Is. and Digby: not common; July 12 to 22.

1996. *Orthodes crenulata* Butler. MacNab's Is.; Aug. 15, 1906; Digby; common; July 15 to Aug. 3.

1997. *O. cynica* Guenée. MacNab's Is.; July, 1907; Digby; very common; July 22 to 28.

1998. *O. vecors* Guenée. MacNab's Is.; June 3, 1910. Digby; July 15, 1905; Aug. 31, 1908; June 8, 1908.

2009. *Crocigrapha normani* Grote. Digby; Feb. 3, 1905; June 18, 1907.

2015. *Graphiphora oviducta* Guenée. Digby; June 6, 1907; June 6, 1908.

2024. *G. furfurata* Grote. Digby.

2040. *G. alia* Guenée. MacNab's Is. and Digby; May, 1906; June 13, 1907; May 7, 1908.

2077. *Lithomoia germana* Morrison. Digby; quite common; Aug. 31 to Sept. 13.

2091. *Xylina laticinerea* Grote. Digby; Sept. 1, 1906.

2093. *X. ferrealis* Grote. Digby; Sept. 20, 1906.

2094. *X. signosa* Walk. Digby; not common; Aug. 23 to Sept. 10.

2097. *X. bethunei* G. & R. Digby; Sept. 2, 1905; Aug. 6 to 20, 1906; nine specimens.

2100. *X. fagina* Morrison. MacNab's Is; June 3, 1910. Digby; July 1, 1905; April 25, 1907.

2107. *X. tepida* Grote. MacNab's Is.; April 7, 1904. Digby; Sept. 28, 1907.

2108. *X. baileyi* Grote. Digby; Sept. 17, 28, 1907.

2111. *X. thaxteri* Grote. MacNab's Is.; June 12, 1909.

2112. *X. pexata* Grote. Digby; March 14; 1906; Sept. 17, 1906.

——. *X. fletcherii.* Digby; Sept. 20, 1906; Sept. 19, 1907.

2115. *Litholomia napæa* Morrison. MacNab's Is.; rare.

2118. *Calocampa nupera* Lint. MacNab's Is.; rare.

2121. *C. curvimacula* Morrison. MacNab's Is. and Digby; not common; July and Aug.

2122. *Cucullia convexipennis* G. & R. MacNab's Is. and Digby.

2127. *C. asteroides* Guenée. MacNab's Is. and Digby; not common; July.

2132. *C. intermedia* Speyer. MacNab's Is. and Digby; June 26 to July 27.

2149. *Sphida obliqua* Walk. Digby; June 9, 1907.

2161. *Gortyna velata* Walk. MacNab's Is. and Digby; not common; Aug. 2 to 22.

2162. *G. nictitans* Bork. MacNab's Is. and Digby; common; Aug.

2199. *Xanthia flavago* Fabr. MacNab's Is. and Digby; not common; Sept. 9 to 18.

2203. *Brotolomia iris* Guenée. Digby and MacNab's Is.; July 18, 1907; not common; June.

2204. *Trigonophora periculosa* Guenée. MacNab's Is. and Digby; common; July 25 to Aug. 6.

2204a. *T. periculosa* var. *v-brunneum* Grote. Very common at Digby July 29 to Aug. 12.

2206. *Eucirrœdia pampina* Guenée. MacNab's Is. and Digby; common; Aug. 28 to Sept. 21.

2207. *Scoliopteryx libatrix* Linn. MacNab's Is. and Digby; common; Oct. 4 to 9.

2217. *Cosmia paleacea* Esper. Digby; common; Aug. 24 to 31.

2222. *Orthosia bicolorago* Guenée. Sept. 19, 28, 1907.

2222a. *O. bicolorago* var. *ferruginoides* Guenée. MacNab's Is. and Digby; very common; Aug. 14 to Sept. 11.

2235. *Parastichtis discivaria* Walk. Digby; not common; Aug. 20 to 29.

2241. *Scopelosoma walkeri* Grote. Digby; May 7, 1906.

2242. *S. sidus* Guenée. Digby; April 3, 1906.

2247. *Glœa inulta* Grote. MacNab's Is.; one specimen; 1900; Digby; common; Aug. 4 to 31.

2261. *Ipimorpha pleonectusa* Grote. MacNab's Is.; Sept. 14, 1906.

2307. *Rhodophora florida* Guenée. MacNab's Is.; July 19, 1906 (one specimen). Common at Digby; July 7 to 14.

2473. *Polychrysia formosa* Grote. MacNab's Is.; Aug. 17, 1906.

2475. *Plusia æroides* Grote. MacNab's Is. and Digby; common; July and Aug.

2476. *P. balluca* Geyer. Digby; 1904. MacNab's Is.; Aug. 20, 1907.

2479a. *Euchalcia festucæ* var. *putnami* Grote. MacNab's Is. and Digby; not common; July.

2480. *E. venusta* Walk. MacNab's Is.; 20 July, 1908 (Perrin). Halifax (Downs).

2481. *Eosphoropteryx thyatiroides* Guenée. MacNab's Is; rare. Digby; Aug. 14, 1906.

2482. *Autographa mappa* G. & R. MacNab's Is. and Digby; Aug. 5, 1905; July 20, 1906; very rare.

2483. *A. bimaculata* Stephens. MacNab's Is. and Digby; not common; Aug. 3 to 23.

2488. *A. precationis* Guenée. MacNab's Is.; scarce. Digby; Aug. 10, 1906.

2491. *A. flagellum* Walk. MacNab's Is. and Digby; July 25, 1907.

2496. *A. brassicæ* Riley. MacNab's Is.; Sept. 23, 1909.

2501. *A. alias* Ottol. MacNab's Is.; scarce. Digby; Aug. 8, 1906.

2503. *A. altera* Ottol. (?) MacNab's Is.; rare.

2505. *A. rectangula* Kirby. MacNab's Is.; plentiful. Digby; scarce; Aug.

2509. *A. selecta* Walk. MacNab's Is.; rare. Digby; Aug. 21, 1906.

2515. *A. epigæa* Grote. MacNab's Is.; common.

2517. *A. ampla* Walk. Digby; July 8, 1905; July 20, 1906. MacNab's Is.

2519. *A. falcigera* Kirby. MacNab's Is. and Digby; common; June, Aug., Sept.

2555. *Alabama argillacea* Hübn. MacNab's Is.; Oct. 8, 1905.

2568. *Rivula propinqualis* Guenée. Digby; Aug. 7, 1907; July 6, 1908.

2601. *Eustrotia albidula* Guenée. Digby; common; June 15 to July 13. MacNab's Is.; one specimen; June 14, 1906.

2604. *E. concinnimacula* Guenée. Digby; 1904; June 20, 1908.

2612. *E. apicosa* Haworth. MacNab's Is. and Digby; Sept. 3, 1907; June 25, 1908.

2613. *E. carneola* Guenée. MacNab's Is.; July 9, 1909. Digby; July 7, 1906; June 25, July 20, 1908.

2622. *Lithacodia bellicula* Hübn. Digby; 1904.

2715. *Metathorasa montifera* Guenée. MacNab's Is. and Digby; not common; June 19 to 22.

2716. *Euherrichia mollisima* Guenée. Digby; June 22, 1906.

2725. *Pangrapta decoralis* Hübn. MacNab's Is. and Digby; common; June 7 to Aug. 14.

2734. *Homopyralis contracta* Walk. MacNab's Is.; Aug. 9, 1909. Digby; rare; June 28, 1906; Aug., 1907; June 17, 1908.

2754. *Drasterea erechtea* Cramer. MacNab's Is. and Digby; common; Aug.

2755. *D. crassiuscula* Haworth. Digby; common; May 5 to 10; Aug. 10 to 20.

2769. *Meliopotis limbolaris* Geyer. North West Arm, Halifax; Aug. 15, 1909 (Perrin). Digby; 1904; July 28, 1907; June 17, 1908.

2826. *Catocala relicta* Walk. MacNab's Is.; scarce. Digby; not common; Aug. 17 to Sept. 15.

2826a. *C. relicta* var. *bianca* Edw. Digby; rare; Sept. 1 to 15.

2830. *C. concumbens* Walk. MacNab's Is. and Digby; common; Aug. 11 to Sept. 28.

2848. *C. unijuga* Walk. Digby; common; Aug. 10 to Sept. 11.

2854. *C. briseis* Edw. MacNab's Is.; Aug. 12, 1905. Digby; not common; Aug. 22 to Sept. 4.

2857. *C. parta* Guenée. MacNab's Is. and Digby; Aug. 17 to Sept. 14.

2864. *C. ultronia* Hübn. Digby; not common; Aug. 30 to Sept. 4.

2865. *C. ilia* Cramer. Digby; Sept. 31, 1906.

2872. *C. cerogama* Guenée. Digby; Aug. 25, 1906.

2884. *C. antinympha* Hübn. Digby; not common; Aug. 14 to 26.

2886. *C. cœlebs* Grote. Digby; not common; Aug. 10 to 24.

2892. *C. polygama* Guenée. MacNab's Is.; Aug. 25, 1904.

2892a. *C. polygama* var. *cratægi* Saunders. MacNab's Is; Aug. 17. 1907. Digby; Sept. 17, 1907.

2900. C. *præclara* G. & R. Digby; Sept. 17, 1907.

2905a. *C. gracilis* var. *sordida* Grote. MacNab's Is. and Digby; very common; Aug. and Sept.

2921. *Parallelia bistriaris* Hübn. MacNab's Is. and Digby; June 22 to Aug. 12:

2977. *Zale horrida* Hübn. Digby; very common; June 15 to 24.

2983a. *Ypsia undularis* var. *æruginosa* Guenée. Digby; common; June.

2986. *Homoptera lunata* Drury. MacNab's Is. and Digby; very common; May 17 to June 22.

2986a. *H. lunata* var. *edusa* Drury. MacNab's Is. and Digby; common; June.

3002. *H. duplicata* Bethune. Digby; scarce; June 6 to 20.

Subfamily Hypeninæ.

3008. *Epizeuxis americalis* Guenée. MacNab's Is. and Digby; common; Aug. 3 to 10.

3009. *E. æmula* Hübn. MacNab's Is. and Digby; common; Aug.

3012. *E. lubricalis* Geyer. Digby; not common; July.

3025. *Zanclognatha marcidilinea* Grote. Digby; common; Aug.

3036. *Philonetra metonalis* Walk. Digby; July 18, Aug. 2, 1907; June 30, 1908.

3044. *Renia sobrialis* Walk. MacNab's Is.; Aug. 10, 1909. Digby; Aug., 1906.

3045. *R. clitosalis* Walk. Digby; Aug., 1906.

3049. *Bleptina caradrinalis* Guenée. MacNab's Is.

3054. *Heterogramma pyramusalis* Walk. MacNab's Is.

3058. *Palthis angulalis* Hübn. Digby; not common; June.

3060. *Capis curvata* Grote. MacNab's Is.; Aug. 22, 1909; July 10, 1910.

3063. *Lomanaltes eductalis* Walk. Digby; June 24, 1907; June 27, July 21, 1908.

3065. *Bomolocha baltimoralis* Guenée. Digby.

3066. *B. bijugalis* Walk. MacNab's Is.; Aug. 8, 1907. Digby.

3072. *B. toreuta* Grote. Digby; July 27, 1907; June 27, 1908.

3079. *Plathypena scabra* Fabr. Digby; common; Aug. 29 to Sept. 8.

3080. *Hypena humuli* Harris. MacNab's Is.; very common. Digby; scarce; Aug.

Family NOTODONTIDÆ.

3092a. *Melalopha apicalis* var. *ornata* G. & R. MacNab's Is. and Digby; July 2, 1907.

3094. *M. inclusa* Hübner. MacNab's Is.; June 10, 1910.

3096. *M. albosigma* Fitch. MacNab's Is.; July 4, 1907.

3098. *Datana ministra* Drury. MacNab's Is. and Digby; not common; July.

3111. *Hyperæschra stragula* Grote. Digby; March 15, 1905; June 30, July 12, 1906.

3118. *Pheosia dimidiata* H.-S. MacNab's Is; one specimen emerged July 3, 1910.

3120. *Lophodonta furruginea* Pack. MacNab's Is.; June 15, 1906.

3123. *Nadata gibbosa* S. & A. MacNab's Is.; rare.

3125. *Symmerista albifrons* S. & A. Digby and MacNab's Is.; not common; June 16 to July 5.

3137. *Heterocampa manteo* Doubl. MacNab's Is.

3140. *H. biundata* Walk. MacNab's Is. and Digby; July 2, 1907.

3148. *Schizura ipomϾ* Doubl. MacNab's Is.

3148b. *S. ipomϾ* var. *cinereofrons* Pack. MacNab's Is.

3151. *S. unicornis* S. & A. MacNab's Is. and Digby.

3153. *S. badia* Packard. MacNab's Is.; Aug. 6. 1907; Aug. 7, 1910.

3164. *Harpyia scolopendrina* Boisd. Halifax (Downs).

3164b. *H. scolopendrina* var. *albicoma* Strecker. MacNab's Is.; Aug. 10, 1907.

3166. *Gluphisia septentrionalis* Walk. MacNab's Is.; Aug. 16, 1906.

Family THYATIRIDÆ.

3173. *Habrosyne scripta* Gosse. MacNab's Is. and Digby; common; June 22 to Aug. 3.

3176. *Pseudothyatira cymatophoroides* Guenée. MacNab's Is. and Digby; July 21 to 29.

3177. *P. expultrix* Grote. MacNab's Is. and Digby; common; June 19 to July 19.

Family LIPARIDÆ.

3187. *Notolophus antiqua* Linn. MacNab's Is. and Digby; not common; Sept. and Oct.

3190. *Hemerocampa leucostigma* S. & A. MacNab's Is. and Digby; very common; Aug. and Sept.

3195. *Olene plagiata* Walk. MacNab's Is.; Aug. 6, 1907.

3197. *Euproctis chrysorrhœa* Linn. Digby; July 14, 1905; first specimen taken in Nova Scotia.

Family LASIOCAMPIDÆ.

3208. *Tolype velleda* Stoll. MacNab's Is.; Oct. 4, 1909.

3214. *Malacosoma americana* Fabr. Digby and MacNab's Is.; rare; July.

3221. *M. disstria* Hübn. Digby; very common during July 1905, less so in 1907, scarce 1908.

3223. *Epicnaptera americana* Harris. Digby; Jan. 17, 1905; bred; and MacNab's Is.

Family PLATYPTERYGIDÆ.

3226. *Oreta rosea* Walk. MacNab's Is.; Aug. 4, 1904. Digby; Aug. 2, 1905.

3229. *Drepana arcuata* Walk. MacNab's Is. and Digby; not common; June 16 to July 18.

3229a. *D. arcuata* var. *genicula* Grote. MacNab's Is. and Digby; not common.

3231. *Falcaria bilineata* Pack. MacNab's Is.; Aug. 9, 1909. Digby; July 26, 1907.

Family GEOMETRIDÆ.

Subfamily DYSPTERIDINÆ.

3234. *Nyctobia limitata* Walk. MacNab's Is. and Digby; common; April and May.

3237. *Cladora atrolliturata* Walk. MacNab's Is. and Digby; not common; May 7 to June 13.

3240. *Rachela bruceata* Hulst. Digby; not common; Nov.

Subfamily HYDRIOMENINÆ.

3247. *Alsophila pometaria* Harris. MacNab's Is. Digby; Nov. 23, 1905.

3248. *Eudule mendica* Walk. MacNab's Is; not common. Digby; very common; June 7 to 19.

3256. *Talledega tabulata* Hulst. Digby; June 13, 1907.

3282. *Tephroclystis albicapitata* Pack. MacNab's Is.; not common.

3287. *T. latipennis* Hulst. Digby; July 29, 1908.

——. *T. togata.* Digby; June 18, July 7, 1906; July 22, 1907; June 22-29, 1908.

——. *T. quebecata* Taylor. Digby; Sept. 11, 19, 1907.

——. *T. catskillata.* MacNab's Is.; one, May 5, 1909. Digby; Aug. 18, 1908.

——. *T. mutata.** Digby; July 27, 1908.

3323. *Eucymatoge anticaria* Walk. MacNab's Is.; Aug. 10. 1906. Digby; not common; Aug. 14 to 29.

3327. *E. intestinata* Guenée. MacNab's Is. and Digby

3328. *E. vitalbata* Denis & Schif. Digby.

3329. *Venusia cambrica* Curtis. MacNab's Is.; June 10, 1906,

3330. *V. duodecemlineata* Pack. MacNab's Is.

3331. *V. comptaria* Walk. Digby; July 26, Aug. 29, 1907; June 29 to July 20, 1908.

3332. *Euchœca albovittata* Guenée. MacNab's Is. and Digby; common; June 13 to July 7.

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*The last four species were identified for Mr. Russell, and in his absence the authority for names, which do not appear in Dyar's list, cannot be inserted.—ED.

3337. *Epirrita dilutata* D. & S. MacNab's Is. and Digby; Oct. 10, 1907.

3340. *Hydria undulata* Linn. MacNab's Is. and Digby; common; July 7 to 31.

3348. *Eustroma diversilineata* Hübn. MacNab's Is. and Digby; not common; Aug. 28 to Sept. 11.

3352. *E. prunata* Linn. Digby; not common; Aug.

3353. *E. nubilata* Pack.* Digby; Aug. 3, 1906.

3355. *E. explanata* Walker. MacNab's Is.; Aug. 1, 1909.

3359. *Rheumaptera hastata* Linn. MacNab's Is. and Digby; common; June 12 to July 23.

3361. *R. sociata* Bork. Digby; Aug. 16, 1907; July 14, 1908.

3370. *Percnoptilota fluviata* Hübn. Digby; Sept 11, 1907.

3371. *Mesoleuca ruficilliata* Guenée. MacNab's Is. and Digby; common; July.

3374. *M. lacustrata* Guenée. MacNab's Is.

3376. *M. intermediata* Guenée. Digby; Aug. 3 to 17, 1906.

3379. *M. truncata* Hufnagel. MacNab's Is. and Digby; common; Sept.

3381. *M. silaceata* Hübn. Digby; not common; June 15 to 20.

3383. *M. hersiliata* Guenée. Digby; May 9, 1905; July 22, 1907.

3386. *M. vasaliata* Guenée. MacNab's Is. and Digby; not common; May 22 to June 30.

3387. *Hydriomena sordidata* Fabr. Digby; common; June 1 to 18.

3388. *H. autumnalis* Strömeyer. MacNab's Is.; common.

3390. *H. tæniata* Stephens. Digby; Aug. 16, 1907.

3395. *H. contracta* Pack. Digby; Aug. 10 to Sept.

3401. *H. multiferata* Walk. MacNab's Is.; July 18, 1906; Digby; July 2, 1906.

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*The range of *E. nubilata* is given as "the Pacific States" in Dyar's list, which would cause us not to expect it here.—Ed

3402. *H. latirupta* Walk. MacNab's Is.; July 10, 1906.

3416. *Triphosa dubitata* Linn. MacNab's Is.; Sept. 13, 1909.

3438. *Gypsochroa designata* Hufnagel. McNab's Is.; May 15, 1910.

3449. *Petrophora incursata* Hübn. MacNab's Is.

3450. *P. abrasaria* Herrich-Schaeffer. Digby; July 7, 1906. MacNab's Is., two specimens, July 6, 1906; July 4, 7, 1908.

3457. *P ferrugata* Clerck. Digby; common; June.

3463. *P. fluctuata* Linn. MacNab's Is. and Digby; July 2, 1906; June 29, 1908.

——, *P. planata* Taylor. Digby; July 2, 1906.

Subfamily STERRHINÆ.

3480. *Cosymbia lumenaria* Hübn. MacNab's Is. and Digby; not common.

3486. *Synelys alabastaria* Hübn. Digby; not common; July.

3487. *S. ennucleata* Guenée. Digby; not common; June 28 to July 11.

Subfamily GEOMETRINÆ.

3568. *Eucrostis incertata* Walk. MacNab's Is. and Digby; common; May.

3587. *Aplodes mimosaria* Guenée. MacNab's Is. Digby; June 12, July 1, 1907; June 8 to 28, 1908.

Subfamily ENNOMINÆ.

3603. *Epelis truncataria* Walk. MacNab's Is. and Dgiby; common; June.

3604. *Eufidonia notataria* Walk. MacNab's Is. and Digby; common; June 14 to 24.

3605. *Orthofidonia exornata* Walk. MacNab's Is. and Digby; not common; June.

3606. *O. semiclarata* Walk. MacNab's Is. and Digby; common; June.

3608. *O. vestaliata* Guenée. NacNab's Is. and Digby; June 24 to July 3.

3618. *Psysostegania pustularia* Guenée. MacNab's Is.; Aug. 18, 1906. Digby; July 12 to Aug. 13. Not common.

3619 *Gueneria basiaria* Walker. MacNab's Is.; Aug. 15 1907.

3623. *Deilinia variolaria* Guenée. Digby and MacNab's Is; common; June.

3624. *D. erythremaria* Guenée. MacNab's Is; one specimen; June 25, 1906.

3647. *Sciagraphia granitata* Guenée. MacNab's Is. and Digby; common; May 28 to June 16.

3666. *Philobia notata* Linn. Digby.

3667. *P. enotata* Guenée. MacNab's Is. and Digby; not common; July.

3683. *Macaria glomeraria* Grote. MacNab's Is.; May 25, 1908,

3695. *Cymatophora brunneata* Thunberg. Digby; July 7, 1906; July 6, 1908.

3705. *C. subcessaria* Walk. Digby; not common; July 14 to 22.

3708. *C. wauaria* Linn. MacNab's Is.; July 30, 1906.

3748. *Homochlodes fritillaria* Guenée. MacNab's Is. and Digby; common; June.

3753. *Apœcasia detersata* Guenée. Digby; common; May and June.

3754. *A. deductaria* Walk. MacNab's Is and Digby.

3755. *A. defluata* Walk. MacNab's Is. and Digby; common: May and June.

3764. *Caripeta divisata* Walk. MacNab's Is. and Digby; common; June 18 to July 29.

3780. *Nepytia semiclusaria* Walk. Digby.

3803. *Paraphia subatomaria* Wood. MacNab's Is.; common.

3850. *Cleora pampinaria* Guenée. Digby; Aug. 17, 1907.

3855. *C. larvaria* Guenée. MacNab's Is. and Digby; not common; June 17 to 30.

3858. *Melanolophia canadaria* Guenée. MacNab's Is. and Digby; not common.

3859. *Æthaloptera intextata* Walker. MacNab's Is. and Digby.

3862. *Ectropis crepuscularia* Denis & Sch. MacNab's Is. and Digby; June 6, 20, 1907.

3867. *Lycia cognataria* Guenée. MacNab's Is.; July 11, 1907,

3873. *Nacophora quernaria* S. & A. MacNab's Is.; March 24, 1907.

3884. *Erannis tiliaria* Harris. MacNab's Is.; Sept. 21, 1906 (Perrin). Halifax (Downs).

3886. *Cingilia catenaria* Drury. MacNab's Is.; Sept. 22, 1901. Digby; very common; Sept. 15 to 21.

3898a. *Anagoga pulveraria* var. *occiduaria* Walker. Digby; June 20, 1907; July 6, 1908.

3902. *Sicya macularia* Harris. MacNab's Is.; Aug. 28, 1904. Digby; Aug. 3, 1906.

3908. *Therina endropiaria* G. & R. Digby; June 22, 1907; June 18 to 29, 1908.

3909. *T. athasiaria* Walker. Digby; June, 1908.

3910. *T. fiscellaria* Guenée. Digby; very common; Sept 10 to 22.

3911. *T. fervidaria* Hübn. MacNab's Is.; very common.

3913. *Metrocampa prægrandaria* Guenée. MacNab's Is. and Digby; not common; July 26 to 31.

3922. *Ennomos subsignarius* Hübn. MacNab's Is.; Aug. 9, 1904.

3923. *E. magnarius* Guenée. MacNab's Is.

3925. *Xanthotype crocataria* Fabr. MacNab's Is. and Digby; July.

3927. *Plagodis serinaria* H.-S. MacNab's Is.; June 24, 1904. Digby; June 24, 1905.

3934. *Hyperitis micaria* H.-S. MacNab's Is. and Digby; June 23, 1908.

3939. *Ania limbata* Haworth. Digby; common; Aug.

3941. *Gonodontis hy ochra ia* H.-S. MacNab's Is.; two specimens; July 9, 1909

3944. *G. duaria* Guenée. MacNab's Is. and Digby; June 12, 1907; June 4 to 11, 1908.

3957. *Euchlæna effectaria* Walk. Digby; July 4 to 10, 1906.

3971. *Eut apela kenta ia* Grote. MacNab's Is; three specimen's.

3981. *Metanema inatomaria* Guenée. MacNab's Is. and Digby; not common; July.

3982. *M. determinata* Walk. MacNab's Is. and Digby; not common; July.

3986. *M. quercivoraria* Guenée. MacNab's Is.; June 12, 1906.

3990. *Priocycla armantaria* H. & S. MacNab's Is.; July 21, 1905.

4001. *Azelina anceteria* Hübn. MacNab's Is. and Digby; not common; July.

4007. *Caberodes confusaria* Hübn. MacNab's Is.; June 2, 1906.

4011. *Tetracis crocallata* Guenée. MacNab's Is. and Digby; June.

4016. *Sabulodes lorata* Grote. MacNab's Is. and Digby; common; June 14 to 22.

4026. *S. transversata* Drury. Digby; very common; Sept.

4028. *Abbotana clemataria* S. & A. MacNab's Is. Digby; June 25, 1908.

Subfamily BREPHINÆ.

4037. *Brephos infans* Möschler. MacNab's Is. and Digby; May 7, 1907; May 16, 1908.

Superfamily TINEOIDEA.

Family COCHLIDIIDÆ.

4106. *Tortricidia testacea* Pack. Digby ; June 24, 1907.

Family SESIIDÆ.

4191. *Bembecia marginata* Harris. Digby ; July.

Family PYRALIDÆ.

Subfam PYRAUSTINÆ.

4276. *Hymenia fascialis* Cram. MacNab's s.; two specimens.

4277. *Desmia funeralis* Hübner. MacNab's Is.; rare.

4336. *Evergestis straminalis* Hübner. MacNab's Is. and Digby ; common ; July.

4342. *Nomophila noctuella* D. & S. MacNab's Is.

4347. *Loxostege chortalis* Grote. Digby ; June 17, 1907.

4413. *Phlyctœnia tertialis* Guenée. MacNab's Is.; July 20, 1906.

4418. *Pyrausta fissalis* Grote. MacNab's Is.; Aug. 9, 1909.

4436. *P. fumalis* Guenée. MacNab's Is ; Aug. 1, 1909.

4454. *P. insequalis* Guenée. Digby ; June 5, 1907.

4472. *P. funebris* Ström. Digby ; June.

——. *P. ochosalis* Fitch, MS. (See W. H. Holland's "Moth Book," p. 398, and pl. 47, fig. 57.) MacNab's Is.; rare.

Subfamily PYRALINÆ.

4516. *Pyralis farinalis* Linn. MacNab's Is. and Digby ; July 18, 1905, and Aug. 2, 1907.

4521. *erculia olinalis* Guenée MacNab's Is.; Aug. 7, 1908.

4523. *H. himonialis* Zeller. Digby ; Aug. 2, 1907.

Subfamily CRAMBINÆ

4575. *Crambus agitatellus* Clemens. Digby ; June 9, 11, 1906.

Subfamily PHYCITINÆ.

4832. *Euzophera semifuneralis* Walk. Digby ; July 14, 1906 ; June 5, Sept. 19, 1907.

——. *Palpita hortulata.* (Identified by Prof. C. H. Fernald.) MacNab's Is.; not common. Formerly reported by Dr. J. Fletcher as *Pyrausta generosa* G. & R.

Family PTEROPHORIDÆ.

4962. *Pterophorus homodactylus* Walker. MacNab's Is.

Family TORTRICIDÆ.

Subfamily OLETHREUTINÆ.

5167. *Thiodia aspidiscana* Hübner. Digby.

5296. *Cydia pomonella* Linn. Digby.

Subfamily TORTRICINÆ.

5331. *Epagoge sulfureana* Clemens. Digby ; Aug. 9, 1905.

5352. *Sparganothis violaceana* Robinson. Digby.

5356. *Archips rosaceana* Harris. MacNab's Is : Aug. 16, 1909.

5379. *A. persicana* Fitch. Digby.

Family YPONOMEUTIDÆ.

5537a. *Orchemia diana* var. *betuliperda* Dyar. MacNab's Is.; Sept. 1, 1909.

Family ŒCOPHORIDÆ.

5889. *Depressaria heracliana* De Geer. MacNab's Is.; Aug. 15, 1909.

5893. *Semioscopsis ackardella* Clemens. MacNab's Is.; May 12, 1909.

Family TINEIDÆ.

6236. *Bucculatrix canadensisella* Chambers. Dr. A. H. MacKay, of Halifax, reports this species very common during the last two years, the larvæ attacking the leaves of birches. It has been associated, at least in Pictou, Colchester and Halifax counties, with the birch-leaf sawfly, *Phlebotrophia mathesoni*,* MacGillivray. *Bucculatrix* larvæ eat patches out of the leaves, leaving the epidermis of one side; *Phlebotrophia* larvæ mine between the upper and lower epidermis, forming circular patches deprived of the green central layer of the leaf.

6487. *Tineola bisselliella* Hummel. (Clothes moth). Very common.

6532. *Trichophaga tapetzella* Linn. This may be 6520, *Tinea pellionella* Linn. (the fur moth), there not being a specimen at hand to be certain (Perrin).

6557. *Adela purpura* Walker. MacNab's Is.

Superfamily MICROPTERYGOIDEA.

Family HEPIALIDÆ.

6604. *Sthenopis argenteomaculatus* Harris. Halifax (Downs collection).

6609. *Hepialus mustelina* Pack. MacNab's Is.; Aug. 25, 1907.

6610. *H. gracilis* Grote. MacNab's Is.; Aug. 16, 1907.

**Phlebotrophia mathesoni* MacGillivray may be only a variety of the European species.– ED.

ADDITIONS TO THE CATALOGUE.

The following additional species should be inserted in the foregoing list, as indicated by their respective numbers:

1225. *Hadena lateritia* Hübner. MacNab's Is.; common.

1226. *Hadena cogitata* Smith. MacNab's Is.; June 30, 1910.

1252. *Hadena inordinata* Morrison. MacNab's Is.; June 21, 1910.

1805. *Mamestra congermana* Morrison. MacNab's Is.; July 23, 1907.

——. *Mamestra incallida.* (Identified by Dr. J. B. Smith): MacNab's Is.; June 9, 1909.

2197p. *Pyrrhia umbra* var. *exprimens* Walker. MacNab's Is.: July 30, 1907.

2240. *Scopelosoma tristigmata* Grote. MacNab's Is.; May 21, 1907.

Amended number of nominal species and varieties in the preceding catalogue: Butterflies, 60; moths, 480; total, 540.

Since the preparation of the catalogue, one of the authors, Mr. John Russell, has removed from Nova Scotia, and his present address is Hope Station, British Columbia.

CONCERNING THE EFFECT OF GRAVITY ON THE CONCENTRATION OF A SOLUTE.—BY HAROLD S. DAVIS, B. A., Dalhousie College, Halifax, N. S.*

Read 31st May, 1911.

Suppose that a solution of uniform concentration is placed in a tube of constant cross-section and of vertical height, l, and is exposed to the influence of gravity.

In general the concentration must now change throughout the solution in order to produce equilibrium which obtains after an infinite time.

If (Fig. 1) the height of the tube is represented by M N, and the concentration at any point by a distance x perpendicular to M. N, then x will trace out a line A B representing the concentration of the solution at any point. At the beginning, A B will be a straight line parallel to $x\,y$. At final equilibrium it will be a straight line which is in general inclined to M N. See L. Vegard, Contributions to the Theory of Solutions, *Phil. Mag.*, series 6, no. 77, page 258). For any time t less than infinity, A B will represent the distribution of the solute.

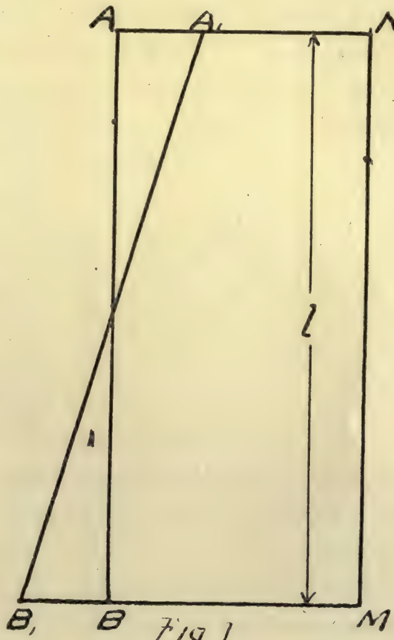


Fig 1

* Published in this part by permission of the council of the N. S. Institute of Science.

In the article referred to above, Vegard proves from considerations of dynamical and thermodynamical equilibrium, that the final distribution of the solute will depend on whether the density of the solution at that particular concentration increases or decreases for an infinitely small increase in concentration. In the special case in which a small change in concentration makes no corresponding change in density, the concentration of the solution will remain uniform throughout even when exposed to gravity.

Suppose now the homogeneous solution is exposed to gravity, its concentration will begin to change, solute flowing from the top to the bottom or vice versa, according as the density at that particular concentration increases or decreases with the concentration. This flow will be comparatively large at first, but will fall away to zero as an exponential function of the time. When equilibrium is reached, there is the same concentration gradient at every height of the column. If now we consider the force of gravity removed, the solution will begin to diffuse back to its initial condition of uniform concentration, and it seems reasonable to suppose that the flow will be exactly similar to that in the original solution, that is it will be comparatively large at first, and will fall away as an exponential function of the time.

If this be true, then the original diffusion flow is exactly similar to one in a tube not exposed to any force such as gravity and where the initial concentration gradient is equal to that which actually exists in final equilibrium in the solution exposed to gravity.

Now it is always assumed that the diffusion of a solute is analagous to the flow of heat, and obeys Fourier's linear diffusion law, and the conditions in the differential equation:

$$D\frac{d^2c}{dx^2} = \frac{dc}{dt}$$

Where T = time.

c = concentration of solute,

x = distance from any fixed plane perpendicular to the direction of flow.

D = a constant for that particular solvent and solute.

Assuming this, the other condition we have is that no solute passes through the limiting layers A N or B M (Fig. 1).

To get this problem into a form suitable for mathematical analysis let us imagine that we have an infinite number of tubes of solution such as in (Fig. 1) of length l, and with a concentration gradient as in final equilibrium. Suppose now we place these together end to end so that the end of greatest concentration in one meets the end of greatest concentration in the other (Fig. 2).

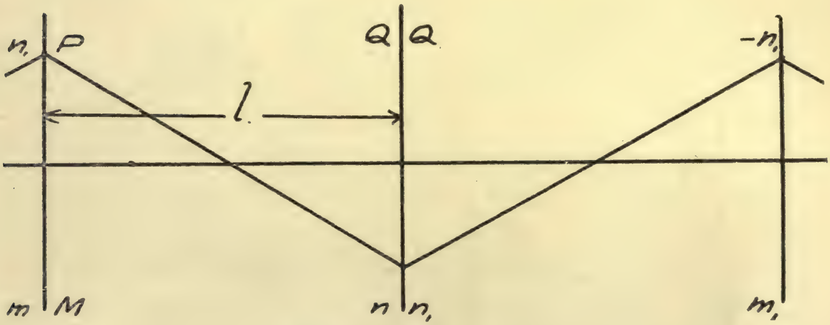


FIG. 2

Diffusion begins and the solute in the tube M N flows in the direction of the gradient and similarly in the other tubes. The concentration at the plane M P therefore decreases and that at n Q increases. *But since there is no gradient at the plane P M or at the plane n Q, so solute can pass through them,* which is the condition required in our problem.

Now, since the concentration in M n obeys Fourier's linear diffusion law, it is a function of the distance x from the plane P M, and of the time T, and may be expanded in a Fourier's series, but since $\Phi(x) = \Phi(-x)$ only cosine terms enter.

Let $\Phi(x) = \left(A_o \times A_1 \text{ Cos } \frac{\pi}{l} x + A_2 \text{ Cos } \frac{2\pi}{l} x + \dots\dots\dots\right)$

$$\text{where } A_m = \frac{1}{l}\int_o^{2l} \Phi(x) \text{ Cos } \frac{m\pi}{l} dx$$

$$\text{where } A_o = \frac{1}{2l}\int_o^{2l} \Phi(x)\, dx.$$

Let (a) be the difference in concentration between the initial and final at the plane PM, which is of course equal to that at the plane NQ

Then at time $T = o$

$$\Phi(x) = a - \frac{2ax}{l} \text{ from } o \text{ to } l$$

$$\Phi(x) = \frac{2ax}{l} - 3a \text{ from } l \text{ to } 2l$$

$$\therefore A_m = \frac{1}{l}\int_o^l \left(a - \frac{2ax}{l}\right) \text{Cos } \frac{m\pi}{l} x\, dx$$

$$+ \frac{1}{l}\int_l^{2l} \left(\frac{2ax}{l} - 3a\right) \text{Cos } \frac{m\pi}{l} x\, dx$$

$$\therefore A_m = \left[\frac{al}{m\pi l} \text{ Sin } \frac{m\pi x}{l}\right]_o^l - \frac{2a}{ll}\left[\frac{xl}{m\pi} \text{ Sin } \frac{m\pi}{l} x + \frac{l^2}{m^2\pi^2} \text{ Cos } \frac{m\pi x}{l}\right]_o^l$$

$$+ \frac{2a}{l}\,\frac{}{l}\left[\frac{xl}{m\pi} \text{ Sin } \frac{m\pi}{l} x + \frac{l^2}{m^2\pi^2} \text{ Cos } \frac{m\pi}{l} x\right]_l^{2l}$$

$$- \left[\frac{3a}{l}\,\frac{l}{m\pi} \text{ Sin } \frac{m\pi}{l} x\right]_o^{2l}$$

$$\therefore Am = \left(\dots\dots \left(\text{Sin } m\pi\right)\right.$$

$$+ \frac{2a}{m^2\pi^2}\left(- \text{Cos } m\pi + \text{Cos } o + \text{Cos } 2m\pi - \text{Cos } m\pi\right)$$

$$= o \text{ when } \underline{\text{“}m\text{”}} \text{ is even}$$

$$= \frac{8a}{m^2\pi^2} \text{ when } \underline{\text{“}m\text{”}} \text{ is odd}$$

In the same way ;

$$A_o = \frac{1}{2l}\int_o^l \left(a - \frac{2ax}{l}\right)dx + \frac{1}{2l}\int^{2l}\left(\frac{2ax}{l} - 3a\right)dx$$

$$= \frac{1}{2l}\left[al - al + 4al - 6al - al + 3al\right] = o$$

So. If $\Phi(x) = \frac{8a}{\pi^2}\left(\text{Cos}\ \frac{\pi}{l}\ x + \frac{1}{9}\ \text{Cos}\ \frac{3\pi}{l}\ x + \frac{1}{2l}\ \text{Cos}\ \frac{5\pi}{l}\ x\right.$

$$\left. + \ldots\ldots\ldots\ldots\ \text{etc}\right)$$

and if $x = l$ then $\Phi(x) = -a$

$x = o$ then $\Phi(x) = a$

$x = \frac{l}{2}$ then $\Phi(x) = o$

which shows that the analysis is correct physically. So that at any time, T

$$\Phi(x) = \frac{8a}{\pi^2}\left(\epsilon^{\frac{-\pi^2 DT}{l^2}}\ \text{Cos}\ \frac{\pi x}{l} + \frac{1}{9}\epsilon^{\frac{-9\pi^2 DT}{l^2}}\ \text{Cos}\ \frac{3\pi}{l}\ x\right.$$

$$\left. + \frac{1}{25}\epsilon^{\frac{-25\pi^2 DT}{l}}\ \text{Cos}\ \frac{5\pi}{l}\ x \ldots\ldots\ldots\ldots\right)$$

which is a Fourier's Series as is readily seen.

If then we have (D) the diffusion coefficient of the substance and (l) the length of the solution tube, and (a) the initial difference in concentration at the limiting layer from that at final equilibrium, we can calculate what will be the value of (a) at any future time.

Three things are necessary that this change in concentration, due to gravity, may be detected in a solution in a reasonable time:

(1) The change in density with concentration must be large at that concentration.

(2) The diffusion constant must be as large as possible.

(3) The substance must lend itself readily to the detection of change in concentration.

It seems likely that some organic solutes and solvents can be found which will have all these factors at a maximum. Data on the first two factors can be found for some substances in Landolt Börnstein's tables, and of these cane sugar seems to be one of the most satisfactory. It has a large diffusion constant, and can be obtained very pure, and its concentration can be accurately estimated by the polariscope.

The following calculations are made for a tube 3 meters in length, and D for cane sugar is taken as .300 as about the mean of the results of Grahm and Arrhenius.

D = .300 where the cm. is the unit of length, the gram the unit of mass, and the day the unit of time.

Calculation of the fall for one year; that is, for a at x = 0, and t = 365.

$$a^t = \frac{8a}{\pi^2}\left(\epsilon^{\frac{-10\times.3\times365}{90000\times1}} + \frac{1}{9}\epsilon^{\frac{-9\times10\times0.3\times365}{90000\times1}} \ldots\ldots\ldots\right)$$

$$= \frac{8a}{\pi^2}\left(\epsilon^{-0.012} + \frac{1}{9}\epsilon^{-0.108} \ldots\ldots\ldots\ldots\ldots\ldots\right)$$

$$= \frac{8a}{\pi^2}\left(0.988. + 0.098 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\right)$$

$= o.9a$ approximately.

So that in a tube of this length the fall in concentration of the sugar solution at the end of one year would only be about one-tenth of the total fall after an infinite time. For a concentration of 1 to 4 this would be about ten per cent. of $10 \times 10^{-7} \times 150 = 15 \times 10^{-6}$ gr. which is a change of concentration that in a solution of that strength would defy detection.

Nor would any material advantage be obtained by either shortening or lengthening the tube, for in the first case the total effect is decreased and soon gets beyond the limit of detection, and in the other, the time to obtain the same percentage fall is increased so as to soon debar experimental verification.

This effect would then be difficult to show in the laboratory, except perhaps for some organic substances, and for these there is no available data on diffusion constants or on density. In nature, however, there are immense bodies of water in the ocaen. These have been there for a long time, though with disturbing factors, and here this effect might be detected.

Practically the only comprehensive and reliable data on the composition of sea water is to be found in the *Reports of H. M. S. Challenger,* Physics and Chemistry, vol. 1. A great number of samples of waters from various latitudes and depths were secured and analysed. The whole results are given. There is also an excellent report on deep-sea temperatures.

Now it will be well to consider whether there are other factors present which would modify the effect in question. These are:

(1) Ocean currents which tend by continually stirring up the water to keep the whole at constant concentration.

(2) The effect of hydrostatic pressure. In the article referred to above, Vegard assumes that the fluid is incompressible and his results are worked out on that assumption. (See also Ostwald, *Solutions,* Muir's translation, 1894, p. 61).

(3) Temperature.

The effect of temperature on the concentration of a solute is difficult to calculate for this reason.

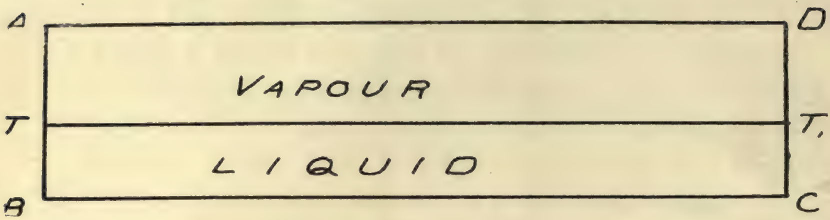


FIG. 3.

Suppose we have the space A, B, C, D (Fig. 3) filled with a liquid and its vapour, and attempt to form a temperature gradient between A, B and D, C. Then, if we keep the planes A, B and C, D at two fixed and different temperatures, the same amount of heat will not pass out through the one at lower temperature as passes in through the one at higher temperature for two reasons:

(1) The liquid itself will circulate and do work because every liquid changes its specific volume with temperature, consequently if it expands with heat, the heated part will rise to the top and give place to cooler and *vice versa* if it contracts.

(2) The vapour will circulate from points of higher vapour pressure to those of lower.

It would then be impossible to obtain a permanent fixed horizontal temperature gradient in a liquid. Perhaps this fact has some bearing on ocean currents and trade-winds, since the tendency is for the water at the poles to be colder than that at the equator. Currents of water and water vapour must result.

The only possible permanent temperature gradient, then, which can exist in a liquid, that changes its specific volume with temperature, is a vertical one. The direction of this gradient will be from top to bottom or *vice versa* according as the liquid expands or contracts with heat.

Suppose such a gradient to exist in a solvent, and let solute be introduced without disturbing the solvent till it is saturated at each point. Then if we neglect the change in specific gravity due to the introduction of solute or suppose it to be less than that due to the temperature gradient, there will be an increase or decrease in the concentration with height, in the case of a

temperature gradient from top to bottom, according as the solubility increases or decreases with temperature.

If such a concentration gradient exists for the saturated solution, there would still exist one, thought not the same in magnitude in solutions not saturated.

Taking the case where increase of temperature is followed by increase of solubility as is the case of most salts in sea water, and where the direction of the temperature gradient and of the flow of heat is downward, as in the ocean, the concentration will increase from the bottom upward.

Now the temperature of the ocean decreases fairly rapidly down to about 800 fathoms, from about 70 F. to 38 F., but after that for the next 1,000 fathoms or more it decreases only 1 to 2 F, so that the temperature of the ocean at great depths is remarkably constant. See *Challenger Reports,* vol. 1, table 6, and also the report on deep-sea temperatures).

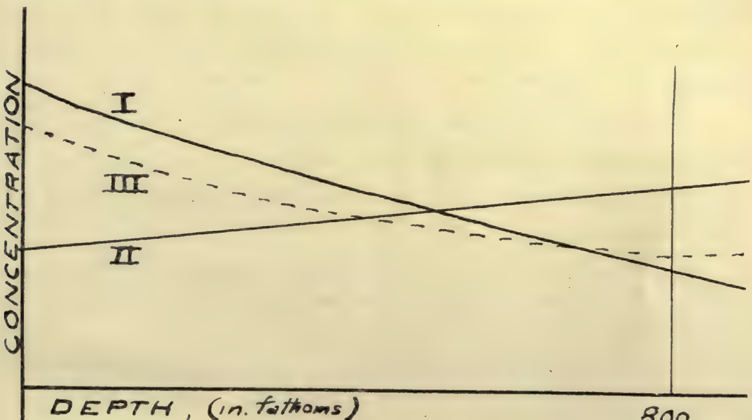


Fig 4

The effect of temperature will thus be a decrease in concentration with depth down to the point where the temperature becomes fairly constant. After this the effect of temperature will gradually die away.

Superposed on this is the effect of gravity, which, as we have seen, will, for inorganic salts, be to increase the concentration with the depth. I have roughly represented the first effect by the curve (1), Fig. 4, and that of the second by curve (2). They will give a resultant curve (3) of change in concentration with depth, and if we suppose the first effect to be the greater near the surface, then the concentration will first decrease, not necessarily uniformly, down to a certain point where the two effects just counterbalance, and from thence will increase steadily to the bottom.

This would account for the actual distribution of the saline contents of sea water as actually found from the summary of the researches on the "Challenger" as given by Dittmar. (See *Encyclopædia Britannica,* 9th edit., "Sea Water").

"In places where there is active dilution at the surface, the salinity as a rule increases down to some 50 or 100 fathoms, but thence downward it follows the general rule, *that is, it decreases down to 800 or 1,000 fathoms, and thence increases steadily to the bottom.*"

Of the data available from the reports on the concentration of the separate constituents, only that of the absorbed gases is of value since the others were determined relatively to the total chlorine content.

Apart from the fact of the large increase of solubility of gases with temperature, the increase of density with concentration, though positive, is extremely small and difficult to measure. (S e Ostwald, Solutions, p. 32).

It was found that:

(1) The amount of nitrogen increases with the depth.

(2) The amount of oxygen decreases with the depth.

But as a matter of fact, the increase of density with concentration for oxygen is greater than for nitrogen, which ought therefore to show a greater increase with the depth.

Dittmar explains the decrease of oxygen as being due to oxidation.

(For the greater part of the mathematics in this paper I am indebted to Dr. H. L. Bronson, of the Department of Physics, Dalhousie College.)

TRANSACTIONS

OF THE

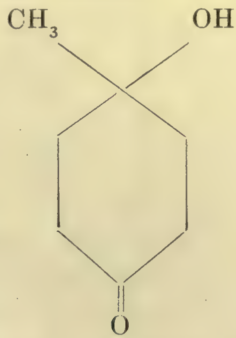
Nova Scotian Institute of Science

SESSION OF 1909-1910

THE ACTION OF ORGANO-MAGNESIUM COMPOUNDS ON QUINONE. —BY CURTIS C. WALLACE.*

Read May 23rd, 1910.

It is generally known that quinone has properties common to both a diketone and a peroxide, but it differs, however, from the former in being a powerful oxidizing reagent and from the latter in forming an oximide compound with hydroxylamine. It is also known that diketone[1] with Grignard's reagents undergoes the pinacone condensation yielding the corresponding pinacone. Further, Bamberger and Blangey[2] obtained a quinol of the structure



with methyl magnesium iodide from toluquinone and xyloquinone, but were unable to get the same from quinone. In

* Contributions from the Science Laboratories of Dalhousie University [Chemistry].

1 Zelinsky, Ber. d deutsch. chem. Ges. 35, 2138, (1902).

2 Bamberger u. Blangey, Ber. d. deutsch. chem. Ges. 36, 1625, (1903).

the following investigation I have endeavored to study more minutely the behaviour of quinone with Grignard's reagents, methylmagnesium iodide, ethylmagnesium bromide and phenylmagnesium bromide.

Experimental.

Quinone and Methylmagnesium Iodide.

5 grams of clean magnesium ribbon were placed in a 500 c.c. flask. The flask was fitted to a reflux condenser, and 30 grams of methyl iodide, dissolved in 40 grams of absolute ether, slowly added through the condenser. Immediately a reaction set in, which was moderated by cooling the flask. When the reaction was about complete, the flask was warmed on a water-bath for an hour. An ethereal solution of 10 grams of quinone was then added, 5 c.c. at a time, with constant shaking, waiting each time until the reaction somewhat abated. The saturation point was obtained by noting when no precipitate formed on the addition of the quinone solution to a test-tube containing a portion of the ethereal solution taken from the flask. On addition of quinone, a violent reaction took place, accompanied by a cracking noise; the reaction product precipitated as a green amorphous mass insoluble in ether. With the object of moderating the reaction, the experiment was repeated, the ethereal solution being this time kept in a freezing mixture (–8°C), with, however, the same results as obtained at ordinary temperature; one molecule of quinone united with two molecules of methylmagnesium iodide. The methylmagnesium iodide quinone compound was found impossible to isolate; it was either insoluble or the solvent caused decomposition.

After allowing the quinone mixture to stand over night, 75 c.c. of cold water and dilute hydrochloric acid enough to acidify the solution were added. No change of colour was apparent on addition of the water, but the acid changed the mixture brown and precipitated a brown flocculent precipitate.

This precipitate was filtered, washed with ether in which it was insoluble, and dried on a filter-paper. The brown powder remaining readily dissolved in ethyl and methyl alcohols and acetone, forming a brown solution, which on evaporation left a black enamel-like residue. It was insoluble in water, and all other common organic solvents, but those mentioned above. It was impossible to obtain it in a crystalline form, but a precipitation of it was obtained by adding water to a concentrated alcoholic solution and evaporating until little or no alcohol remained. This process was not satisfactory, as the compound separated as a colloid in pure water. This substance was not further studied. The total yield from the experiment was only about 0.5 gram.

On evaporating the ethereal solution in a porcelain dish, there remained a green crystalline substance in the central part, with a brown amorphous mass surrounding it. The crystals were removed and in order to obtain more of them the amorphous mass was redissolved in ether and again evaporated. This mechanical process of separation was repeated until a quantity of the crystals was obtained. They were recrystallized from ether and a pure-looking product obtained with a practically constant melting point of 170°C.

An analysis gave the following results:

0.1501 gram of substance gave 0.3646 gram CO_2 and 0.0609 gram H_2O.

	Calculated for $C_{12}H_{10}O_4$.	Found. I
C	66.02%	66.29%
H	4.63%	4.51%

The green crystals gave tests for a quinhydrone; the analysis prove it to be of the formula $C_{12}H_{10}O^4$, or ordinary quinhydrone.

The remaining amorphous tarry residue left from the ether solution consisted of free iodine, some quinhydrone and re-

duction products of the reaction. It was fairly large in quantity, but it was not practicable to isolate any other pure product from it.

Quinone and Ethylmagnesium Bromide.

An ethereal solution of 11 grams of quinone was added gradually, 5 c.c. at a time, to a solution of ethylmagnesium bromide obtained by dissolving 5 grams of magnesium ribbon in 25 grams of ethyl bromide and 50 grams of absolute ether. To ensure a more complete reaction, the mixture was allowed to stand a day with occasional shaking. The blue reaction product which separated out insoluble in ether, was treated with ice water and acidified with dilute hydrochloric acid. The addition of water turned the mixture green, while a further addition of acid turned it brown, separating out at the same time, as in the case of the methyl iodide compound, a brown precipitate insoluble in ether or water. It was observed that although the ethylmagnesium bromide quinone compound was blue, the mixture, after the addition of water, was green and that no such change of colour was noticed with the iodide quinone compound. This was probably due to the fact that both the iodide quinone compound and its products of decomposition were green. Moreover, it was found that the amorphous precipitate, insoluble in ether, was readily soluble in alkalis, producing a green solution; and since magnesium hydroxide, which would be produced by the addition of water, is slightly soluble in water, it would dissolve enough of the substance to colour the mixture green.

The acidified mixture was then filtered and the amorphous precipitate remaining on the filter paper was washed with dilute hydrochloric acid and then with ether and dried. The ethereal solution was next separated and the water solution further extracted with ether. On a partial evaporation of the ether a solid separated, which was filtered and recrystallized from ether. The substance gave practically a constant melt-

ing point of 171°C. Analysis of the substance gave the following results:

I. 0.1326 gram of substance gave 0.3219 gram of CO_2 and 0.0548 gram of H_2O.

II. 0.1336 gram of substance gave 0.3224 gram of CO_2 and 0.0597 gram H_2O.

	Calculated for $C_{12}H_{10}O_4$.	Found. I	II	Mean
C	66.02%	66.21%	65.82%	66.01%
H	4.63%	4.59%	4.96%	4.77%

The sample was pure quinhydrone.

The remaining residue left from evaporation of the remainder of the ethereal solution contained more quinhydrone and a brown tarry decomposition product, but no evidence of any free halide as was the case with the methyl-iodide residue.

The brown powder, obtained from the residue washed in ether, was then further extracted with ether free of alcohol until nothing remained in it that was soluble in ether. It was next boiled in 100 c.c. of water, filtered and washed with water. When dry, it was dissolved in alcohol, filtered and the alcohol evaporated off. A shining black enamel-like residue remained, which decomposed at a very high temperature. When dried in a hot-air closet for two hours at 125°C., analyses gave the following results:

I. 0.1620 gram of substance gave 0.3876 gram CO_2 and 0.0682 gram of H_2O.

II. 0.1560 gram of substance gave 0.3702 gram CO_2 and 0.0678 gram of H_2O.

A slight residue remained after each combustion, but nothing of appreciable weight.

	Calculated for emperical formula $C_6H_5O_2$	Found. I	II
C	66.02%	65.25%	65.88%
H	4.63%	4.67%	4.89%

The compound was extremely hygroscopic. An analysis of the same sample as analysed above, but before the continued drying at high temperature, gave the following results:

0.1298 gram of substance gave 0.2876 gram CO_2 and 0.0619 gram H_2O.

C	60.42%
H	5.29%

The total yield was about 10 per cent of the quinone used. The colour of a concentrated alcoholic solution of this substance is dark brown; one cubic centimeter of this concentrated solution added to 200 c. c. of water is pink; and the addition of a drop of any alkali gives a grass green, while a drop of acid will restore the pink again. This substance reduces an alkaline solution of potassium permanganate, and is apparently oxidized by adding bromine water to an alcoholic solution of it. By either of these treatments an amorphous product with a light yellow colour was obtained.

A method of precipitation of this same substance was developed. About 0.4 gram of the same sample as analysed above, was dissolved in a few cubic centimeters of sodium hydroxide and diluted with water to one liter. The green solution was heated to boiling, acidified with strong hydrochloric acid and then the brown precipitate thus formed allowed to settle. A tall cylindrical jar was used, as it offered a smaller bottom surface and a greater column of water, thus making it possible, when the precipitate had settled, to syphon the solution off, leaving but little with the precipitate. The precipitate was heated again with another liter of dilute hydrochloric acid, 10 volumes of water to 1 volume of acid, Sp. G. 1.2, and allowed to settle. The decantation was repeated three times with the same quantity of dilute acid each time. The fourth dilution was filtered while hot through a hot-water funnel and washed thoroughly with hydrochloric acid of the same dilution as above, the last washing being with

pure water. When dried as much as possible with a suction-pump, it was heated while still on the filter-paper in a hot-air closet for three hours at 125°C. As the precipitate adheres so closely to the filter paper, a suction pump and a platinum cone are practically indispensable in carrying out the above filtration. The brown mass was then removed from the filter paper, dissolved in ethyl alcohol and filtered. On evaporation of the alcohol, the remaining residue was the same as obtained by the other method. An analysis gave the following results:

(The same analyses of the substance as given above, are also given here for comparison.)

0.1492 gram of substance gave 0.3605 gram CO_2 and 0.0598 gram of H_2O.

	Calculated for $C_6H_5O_2$.	Found.	Former Analyses. I	II
C	66.02%	65.89%	65.25%	65.88%
H	4.63%	4.45%	4.67%	4.89%

Quinone and Phenylmagnesium Bromide.

An ethereal solution of 6 grams of quinone was added gradually to a solution of phenylmagnesium bromide obtained by dissolving 3.5 grams of magnesium ribbon in 25 grams of brombenzene and 40 grams of absolute ether. On standing for a day, 75 grams of water and dilute hydrochloric acid, enough to acidify the mixture, were added. The brown precipitate produced was filtered off and the ethereal solution separated as in the former compounds. The precipitate was washed with hot water, then ether, and left to dry. The residue left from dissolving in and evaporating from ethyl alcohol was small. Its properties were similar to the compounds obtained from methyl iodide and ethyl bromide. The product obtained from phenyl bromide and methyl iodide has not yet been analysed. The pure substance, however, could

be obtained easily enough by following either of the methods of procedure described in the separation of the ethyl bromide compound, preferably the hydrochloric acid precipitation method, and the analysis thus procured if materials or time allowed.

On a partial evaporation of the ethereal solution, a quantity of quinhydrone crystallized, which was filtered and recrystallized from ether. It had a practically constant melting point of 170°C.

Analyses gave the following results:

I. 0.1372 gram of substance gave 0.3330 gram CO_2 and 0.0584 gram H_2O.

II. 0.1224 gram of substance gave 0.2984 gram CO_2 and 0.0531 gram H_2O

	Calculated for $C_{12}H_{10}O_4$.	Found. I	II	Mean
C	66.02%	66.19%	66.48%	66.33%
H	4.63%	4.73%	4.82%	4.77%

The carbon and hydrogen were both too high. This was expected as the sample had a slight odour of diphenyl.

The residue remaining after the complete evaporation of the ether was extracted with 75 c.c. of carbon tetrachloride, 25 c.c. at a time. The carbon tetrachloride was then distilled off and there remained in the flask a product which did not boil until the temperature nearly reached 250°C. The portion distilling from 250-260°C. solidified in the condenser tube was collected and crystallized from alcohol. The product consisted of transparent lustrous plates which had a constant melting point of 70°C. An analysis gave the following results, which prove it to be diphenyl.

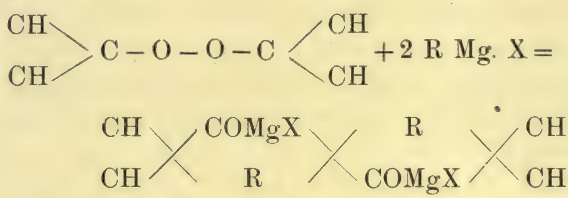
0.1210 gram of substance gave 0.4143 gram CO_2 and 0.0731 gram H_2O.

	Calculated for $C_6H_5C_6H_5$.	Found.
C	93.45%	93.38%
H	6.55%	6.71%

The method of separation was by no means complete, but nearly 2 grams of diphenyl were obtained.

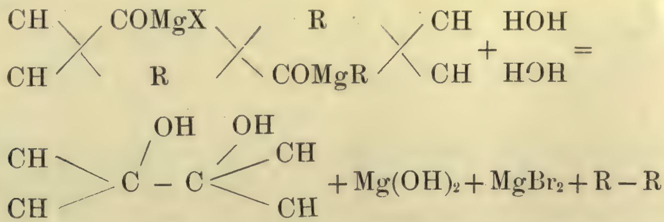
DISCUSSION.

The organo-magnesium halide quinone compounds, which form with such energy on the addition of quinone to the organo-magnesium halide, are not stable, but decompose when exposed to the air. The bromide is blue and the iodide is green. Their formation is possibly in accordance with the following equation :

I. 

Two molecules of the organo-magnesium halide are used to each molecule of quinone.

The formation of the quinhydrone may be explained by the production first of hydroquinone, as shown in the following equation :

II. 

The hydroquinone then reacts with the unattacked quinone, the reaction being expressed by the following equation :

$$\text{III.}\quad C_6H_4(OH)_2 + C_6H_4O_2 = [C_6H_4(OH)_2 + C_6H_4O_2]$$

The production of diphenyl in the action of phenylmagnesium bromide quinone is evidence in support of the reaction as given in equation II.

The investigation of the compound having the empirical formula C_6H_5O obtained from the action of ethylmagnesium bromide on quinone is proceeding; as indicated in the experimental part, similar and probably identical compounds were obtained from methylmagnesium iodide and phenylmagnesium bromide, but until further study has shown the nature of this substance, nothing definite can be stated of the part it plays with regard to the reaction.

No pinacone has been obtained, and no quinol of the structure obtained by Bamberger and Blangey.

These experiments were carried out in the laboratories of Dalhousie University and were suggested by Professor E. Mackay, and I wish, in conclusion, to thank him for the suggestions, helpful criticisms and kindness offered during the progress of the work.

Chemical Department, Dalhousie University,
Halifax, N. S., April 15, 1910.

NOTE ON RECENT EARTHQUAKE IN CAPE BRETON.—BY D. S. MCINTOSH, B. A., M. SC., Lecturer on Geology, Dalhousie University, Halifax, N. S.

Read 14th February, 1910.

On the afternoon of December 20th, 1909, about three o'clock, a distinct earthquake shock was felt in a part of Inverness county, Cape Breton. The disturbed area embraced Port Hood, Mabou, Inverness, Lake Ainslie, Whycocomagh, and Orangedale. From beyond these localities it is not reported. In the towns of Port Hood and Inverness, it was thought that an explosion had taken place in the mines. At Lake Ainslie it is said that a fracture was made in the cement walls of a cellar by the shock. Mr. A. Stirling McLean thus describes it at Orangedale: "While not destructive or terrifying in any way, it was quite pronounced in this locality. One could feel the whole building trembled in a sort or rapid vibratory motion. Tinware and crockery on shelves danced at a great rate. The shock lasted for about five seconds—long enough for one to realize what was taking place. A loud rumbling noise was distinctly heard before the shock which was thought by some persons to be that of an approaching train, by others that of a flue on fire."

The disturbance would appear to have been merely local. At no place on the Island, other than those referred to does it seem to have been noticed. On account of the small area affected, the seat of the disturbance would not likely be far removed from the surface. Nor would it likely be found in the igneous rocks which outcrop in a few places, and probably underlie the younger rocks of the district. Did a fault take place in these rocks, the effect would likely be more widespread than the recent occurrence. The cause of the shock is

rather to be sought for in the sedimentary strata that overlie the igneous rocks. Limestones and gypsum are plentiful in these. The falling in of the roof of a subterranean cavern formed by the action of percolating water on the limestones and gypsum would account for the shock. It is highly probable that such a cave-in, or a fault produced by some readjustment of the carboniferous strata, was the cause of the recent earthquake shock.

THE RUSTS OF NOVA SCOTIA.—BY WILLIAM POLLOCK FRASER, M. A., Macdonald College, P. Q.

Read 23rd May, 1910.

This paper embodies the results of field and microscopic studies of the rusts of Nova Scotia carried on during the years 1908 and 1909.* A few collections were made in 1906 and 1907, but careful and systematic study was begun in the summer of 1908 and has been continued since that time. The most of the collections were made near Pictou and in the surrounding districts, so that it might seem more appropriate to name the paper "The Rusts of Pictou County," but it was thought best to include all the collections made in the province, thus the more inclusive title is used.

Scarcely any attention has been given to this interesting group of fungi in Nova Scotia. The only references that have been found are in Dr. MacKay's "Fungi of Nova Scotia" and "First Supp. List." In these papers (Trans. N. S. Inst. of Science, 11: 141. 1905; 12: 124-126. 1908), the following species are listed: *Puccinia graminis, Gymnosporangium Juniperi, Gymnoconia interstitialis, Coleosporium Solidaginis, Melampsora Medusae, Puccinia acuminata, P. Taraxaci, P. sessilis* (?), *P. suaveolens, P. coronata, P. Menthae, P. Circaeae, P. Cicutae, P. Violae, P. Asteris, P. orbiculata, P. claytoniata, P. rubigo-vera, Uromyces Trifolii, U. caladii, Phragmidium subcorticium, Triphragmium clavellosum, Chrysomyxa Pirolae,* and the forms *Rostelia lacerata, Uredo Agrimoniae, Peridermium balsameum, Per. decolorans* and *Per. elatinum.*

Of the species named in Dr. MacKay's list I now regard *Phragmidium subcorticium* as *Phragmidium americanum, Uredo Agrimoniae* is the uredinial stage of *Pucciniastrum*

* Revised to include collections and studies during 1910 and 1911.

Agrimoniae, Puccinia coronata is described in the following pages as *Puccinia Lolii* and *Puccinia rubigo-vera* as *Puccinia triticina*. *Peridermium decolorans* is the aecial stage of *Melampsoropsis ledicola* and *Peridermium elatinum* of *Melampsorella elatina*. The position of *Gymnosporangium Juniperi* and *Rostelia lacerata* is discussed under the genus *Gymnosporangium*.

In the present paper 92 species and 2 forms are described. A few of these have not been previously reported from North America.

In the general discussion and in some of the notes I am indebted to the literature of the rusts. A list of the works consulted will be found at the end of the paper.

INTRODUCTION.

The *Uredinales* (*Uredineae*) constitute a large group of fungi which are parasitic on flowering plants and ferns. Their structure consists of an inconspicious mycelium in the tissues of the host plant and more or less conspicious spores that usually break through the epidermis and appear as powdery masses or crusts. The vegetative mycelium is similar throughout the group, but the spores produced are unlike so that a study of the rusts is largely a study of the spore forms and their relation to each other and to the host plants. The mycelium eventually gives rise to the teliospores which are generally regarded as the last stage. Spores of five kinds are produced, though they are not all present in every species. Arthur has proposed new terms for these spores, which are used throughout this paper. The list below gives in order the term proposed by Arthur and the more commonly used term for each spore form:

Basidiospore, sporidium.
Pycniospore, spermatium.
Aeciospore, aecidiospore.
Urediniospore, uredospore.
Teliospore, teleutospore.

These spores always follow each other in a definite order; that is, first pycniospores, then aeciospores, urediniospores, and lastly teliospores. One or more of the spore forms may be absent in certain genera or species, except the teliospores, but the spore succession is the same. The basidiospores are produced on a short promycelium developed directly from the teliospore and are thus always present. The largest number of rusts have all the spore forms present; the next largest is the series with all the forms suppressed except the teliospores; then the series with the urediniospores absent, and the smallest number is that in which the aeciospores are wanting. Not much attention has been given to the presence or absence of the pycniospores, for they seem to be present in a great majority of species, though wanting in a few.

Mycelium.

The vegetative mycelium of the rusts is very inconspicuous. It is much branched, colourless, septate and usually ramifies in the walls of the cells, sending haustoria into the cavities. It may be localized or it may permeate the whole plant, and in the latter case is often perennial. Thus the fungus may appear in the same plant year after year without spore infection. In *Puccinia obtegens,* the rust of the Canada thistle, the mycelium lives in the upper part of the rootstock during the winter and infects the young shoots in the spring. In the "Orange Rust of Raspberry" (*Gymnoconia interstitialis*) the aecial mycelium is perennial in the canes and thus lives from year to year.

Eriksson has advanced the theory that the mycelium may live in the cells of the host in the form of a plasma intimately mixed with the protoplasm of the host, and that under favourable conditions, as in the spring, this *mycoplasm* develops into the ordinary mycelium. This would account for the wintering of many rusts where the aecial hosts are not found and for the sudden outbursts that often occur in the cereal rusts.

The mycelium often produces abnormal growths. The most conspicuous in this region is the "witches' broom" of the balsam fir and the elongated and abnormally thickened stems of the bluberry due to the telial stage of *Calyptospora columnaris.* Some species of the genus *Gymnosporangium* produce spherical galls on the cedar, but they do not seem to have been collected in Nova Scotia. In these cases the mycelium is perennial, but even localized mycelium may produce swellings and deformation especially in the stalks and midribs of the leaves. This is so in the case of the aecial stage of *Puccinia sambuci* which is common in the spring on *Sambucus canadensis.*

Pycniospores.

The pycniospores are produced in a pycnium (pycnidium, spermagonium) which is a small inconspicuous, punctiform body. It is usually flask-shaped averaging 100-150μ in diameter, formed immediately beneath the epidermis, with the narrow neck protruding in order to discharge the spores into the air. Usually the opening is provided with a small tuft of hairs. Sometimes the pycnium is formed immediately beneath the cuticle and is then more or less hemispherical or conical. The pycnia are usually on the opposite side of the leaf from the spore-form accompanying them, but sometimes on the same side when usually they surround the accompanying form. Their position, arrangement, form, color and size are characters of some taxonomic value. Usually pycnia appear after infection by basidiospores without any regard to the kind of spore that is to follow: thus, though they usually precede the aecia, they may accompany the other spore forms when aecia are wanting.

The pycniospores are very small, oval or rounded bodies a few microns in length (about 5-8μ). They are produced within the pycnium in short chains from converging hyphae and are held together by a viscid sugary secretion, which sometimes attracts insects. As far as is known these spores have

no function nor any connection with the further development of the fungus. They may be made to grow and bud in a nutrient solution but nothing further has been obtained. It may be that they had some sexual function that has been lost, but there is not much evidence to support this view.

The pycnium is rarely absent in the life cycle, but it only occurs once, not being repeated with each generation. If the aecia repeat, spermagonia only occur with the first generation. If the pycnium accompanies the uredinia it does not repeat. In the case of the teliospore it has not been established whether it accompanies each generation or not.

Aeciospores.

The mycelium, which results from the entrance of the germ tube of a basidiospore after it has produced a certain number of pycnia, soon develops aeciospores. Within the plant tissues hyphae collect together into a compact mass growing perpendicular to the surface of the host, and from the closely crowded hyphae the spores are cut off in basipetal succession so that they are produced in chains. At first sterile cells alternate with the spore cells, but these usually disappear by the time the spores are mature. The outer layer of hyphae usually becomes a wall or peridium, which surrounds the spore mass, and after the rupture of the epidermis usually becomes cylindrical or cupshaped. Sometimes the peridium is absent or it may be replaced by paraphyses as in the genus *Phragmidium*. The spore mass with its peridium or paraphyses is called an aecium or aecidium. The spores are at first polyhedral from mutual pressure, but they soon become free and are then usually globose or ellipsoid in shape. The wall is usually colorless (deep brown in the genus *Gymnosporangium*) with verrucose sculpturing. The roughened wall aids the spores in adhering to the host plant. The contents are chiefly orange-red or orange-yellow and in many cases soon become colourless. Eventually the aecia rupture the

epidermis, the peridium breaks open, sometimes in a characteristic way, and the spores escape. They are most effectively distributed by the wind.

Sometimes all unconnected aecia are placed in the form-genus *Aecidium,* but other form-genera are used, based on the presence or absence or form of the peridium. Thus, when the peridium is elongated and dehisces by longitudinal slits, the aecia are assigned to the form-genus *Roestelia;* when it is extended and ruptures irregularly, to *Peridermium;* when absent, to *Caeoma;* the other forms in which the peridium is usually cupshaped or cylindrical, to the form-genus *Aecidium.*

Aeciospores are provided with germ-pores, but they are usually visible only at germination. They germinate readily in water in a few hours. A germ tube is pushed out from one germ pore and the contents of the cell soon pass into the tube. On the host plant the tube enters through a breathing pore.

Botanists differ as to the length of time that aeciospores retain their germinating power. Plowright found they retained it only a few hours, Klebahn found they retained it for weeks, others found them uncertain.

The aecia that develop from the mycelium resulting from basidiospore infection are called "primary" aecia. When the complete series of spore-forms is present no further aecia are formed, but if the uredinia are wanting the aecia may repeat themselves for some time. That is, aeciospore infection may take place and produce aecia. These are called "secondary" aecia.

Urediniospores.

The urediniospores are produced in spore masses or cushions called uredinia, which usually rupture the epidermis and expose the spores as a dusty mass. They may develop from mycelia produced from the entrance of the germ tube of a basidiospore, an aeciospore or another urediniospore. Mycelial hyphae become crowded together in the host plant

at certain points; from this intertwined hyphal mass a number of branches are given off perpendicular to the surface of the host, and from each of these branches a urediniospore is produced. Sometimes paraphyses are present as in *Melampsora* and *Phragmidium,* and in a few genera a peridium is produced as in *Pucciniastrum* and *Melampsoridium.*

The urediniospores are usually produced singly on pedicels which soon fall away, but sometimes in chains, as in *Chrysomyxa* and *Coleosporium.* When arising in chains they resemble aeciospores, but the order of development will distinguish, the aeciospores always being produced first. The urediniospores are always unicellular, with verrucose or echinulate walls. They are never smooth, and are usually coloured brown. Two or more germ-pores (rarely one) are present which are usually evident. As the number is often definite, it sometimes forms a character of value in the determination of the species.

The urediniospores germinate readily in water, as in the case of the aeciospores. When mature and under favourable conditions on the host plant a germ tube is pushed out through one of the germ pores, which grows very rapidly, and the nucleus of the spore soon passes into it. When it reaches a breathing pore the tip swells into a vesicle, the appressorium, into which the protoplasm of the tube collects. A thin process passed down through the pore and swells into a vesicle in the respiratory cavity, the protoplasmic contents soon pass into the internal vesicle. Tubes or hyphae are soon formed from this vesicle which make their way among the cells. The development of the haustorium begins as a minute process from the hypha, which pierces the cell wall and at once swells up at its distal extremity into a minute head. Soon this grows out, often as an irregularly branched or variously shaped body. In many cases the growth is directed toward the nucleus and infection is complete. (Ward. Phil. Trans. Roy. Society, London, B., 196: 29-46. 1902).

The urediniospore is primarily a spore for the rapid distribution of the fungus so that it may repeat, that is the uredospores may infect the host plant. Often the first formed generation which appears in early spring and originates either from basidiospore infection, aeciospores, or from perennial mycelium, are called "primary" uredinia, and the second generation which develops from uredospore infection are called "secondary" uredinia. The primary uredinia are usually larger and more richly coloured, as in *Puccinia obtegens*.

In countries where the aecial host is absent and the urediniospore propagates the fungus, there is a tendency to abundant development of this stage, as in *Puccinia graminis* in Australia. This rust has lost the power to infect the barberry there and urediniospores are produced abundantly, almost to the exclusion of the teliospores.

Urediniospores retain their germinating power for some time. Bolley states that the uredospores of *P. graminis* in certain cases may survive the winter even in North Dakota, and thus carry the fungus over that period.

Amphispores.

Another kind of urediniospore which has thickened walls and persistent or subpersistent pedicels is found in some species of gramineous rusts. The sori resemble telia and the spores have been mistaken by some observers for teliospores. They can be separated from the true teliospores by the presence of several germ-pores. They have been germinated in 1901 by Carleton and later by Arthur, and the germ tube of the urediniospore was the result. They have not been found in any species represented in Nova Scotia.

Arthur states that they belong to species having their main development in arid or semi-arid regions. They occur only in the United States and Mexico, except one species in India. Arthur (Bull. Torr. Bot. Club 32: 35. 1905) gives a list of five species which he found to possess amphispores. All are from

the western United States and Mexico. The amphispore is evidently a uredospore which has developed the function of a teliospore.

Teliospores.

These are the last spores of the life cycle. It may possibly be that in some cases they are absent, but usually it is simply a case of not having been found. Teliospores are very varied in their forms and on this account have been used largely for purposes of classification. More stress is now laid on other characters.

They arise like the urediniospores in sori called telia or teleutosori, beneath the cuticle or the epidermis. They usually break through the epidermis at length, though they may remain covered. The sori may be pulverulent or compact and often dark in colour, though sometimes colourless or bright coloured. They may be borne on pedicels or sessile. In one genus (*Endophyllum*) not represented in North America the teliospores originate in chains and are surrounded by a peridium regarded as the test of the teliospore. The walls of the teliospores are usually much thickened and may be smooth or verrucose, but never echinulate. Sometimes finger-like projections are present at the apex, as in *Puccinia Lolii.* The number of cells varies from one in *Uromyces* to several as in *Phragmidium.* The number of germ pores in a cell is usually one. In *Uromyces* it is always placed at the apex. In the genus *Phragmidium* and *Gymnosporangium* there are several in each cell.

The telia as in *P. "rubigo-vera"* is often divided into compartments by modified hyphae, which have been called paraphyses, but Arthur regards this as a stroma and not part of the sorus; he regards such sori as compound.

Some teliospores germinate at maturity on the host plant. But the teliospore is primarily a winter spore, whose purpose is to tide the plant over winter, and the majority will not

germinate unless exposed to the weather for some time. If kept inside during the winter germination does not follow even if placed under favourable conditions.

After exposure to the weather for some time, they usually germinate under favourable conditions, though germination is somewhat uncertain. A tube emerges from the germ pore and soon divides into four, each segment is called a basidium and produces on a sterigma a small, usually hyaline spore. These spores, called basidiospores (sporidia), when they reach a suitable host germinate, the germ tubes make their way through the epidermis and infection results.

When the teliospores germinate at once usually the other spore forms are suppressed. They are not lost, however, as they occasionally make their appearance. When the teliospores germinate at once the germ-tube of the basidiospore is said to enter at the breathing pore.

Mesospores.

In many rusts of the genus *Puccinia,* beside the usual two-celled spores large numbers of the single-celled spores are formed. These resemble the teliospores and function like them, the only difference being in form and the number of cells. They are called mesospores. They are common, especially in some species of the grass and sedge rusts. The presence of these one-celled spores seems to indicate a close relationship to the genus *Uromyces.* It is possible that the genus *Puccinia* developed from *Uromyces.*

Heteroecism.

Many rusts pass part of their life cycle on one plant and part on another, while in some species the whole life cycle is confined to one host plant. Those belonging to the former are called heteroecious species and the latter autoecious species. In heteroecious species one host plant bears the pycnia and aecia, the other the uredinia and telia. Usually the host plants

are not nearly related. Thus the species belonging to *Gymnosporangium* have their aecial stage on a tribe of the rose family while the telial stage is on conifers. The grass and sedge rusts usually have their telial stage on the *Compositae,* though there are many exceptions. All the grass and sedge rusts are heteroecious with one or two exceptions. Common autoecious rusts are those belonging to the genus *Phragmidium;* other species are *Puccinia Menthae, P. Violae, Uromyces Limonii* and *U. Polygoni.*

When different forms occur together on the same host plant they are often assumed to belong to the same species, but it is not always safe to do so, without the test of infection experiments.

In the largest number of heteroecious rusts the teliospores are formed at the close of the season or of the life of the host, and rest during the winter. The aecial host is infected in the spring, and the alternate host from the aeciospores. That is the case in *Puccinia graminis* and many other rusts. In other cases the telial mycelium hibernates, the teliospores are produced in the spring and germinate immediately, and the basidiospores infect the aecial host, as in *Chrysomyxa ledicola.* Again the telial mycelium may be actually perennial, the teliospores formed in the spring and germinating infect the aecial host, the aecial mycelium lasting only during the summer as in *Gymnosporangium.* There are other types in which the aecial mycelium hibernates, or the mycelium of both generations may be perennial.

The aecia of heteroecious rusts develop only from mycelium formed by basidiospore infection, the aecia do not repeat, nor can the basidiospores produce infection in the host plants in which the telia are produced. The mycelium that bears telia and uredinia arises only from infection by aeciospores or urediniospores. The rust, however, may be propagated by the urediniospores for some time, probably indefinitely. In Australia *P. graminis* has lost the power to infect the barberry

and, as far as known, aecia are never produced, yet it is very common.

The heteroecism of rusts was first suspected and established in the wheat rust, *P. graminis.* For years before botanists made the discovery, practical farmers suspected that the barberry was connected with the spread of wheat rust. In 1760 a law was passed in the State of Massachusetts for the destruction of barberry bushes. In 1816 Schoeler, a Danish schoolmaster, planted small barberry bushes in the middle of a field of rye and found that the rye around those bushes became rusted while not a rust spot could be found in the rest of the field. He also carried rusted barberry leaves into a field of rye, and rubbed them on the rye plants till he could see the "yellow dust" of the barberry leaves adhering to the plants. These plants were marked and were found to be the only ones in the whole field which became infected with rust. But botanists took no notice of these experiments or of farmers' observations, as they believed the barberry fungus and the rust on rye belonged to different genera. Tulasne showed that the uredinia and telia, which up to this time had been regarded as different genera, were connected. In 1861 De Bary pointed out that many of the rusts had urediniospores and teliospores and also that the latter gave rise to aeciospores, and conversely the aeciospores to urediniospores. In 1864 he sowed the teliospores of *Puccinia graminis* on barberry and produced aecia, and in 1865 he sowed aeciospores on rye and produced uredinia and telia, thus establishing the connection of the different forms. However, it was not till about 1880 that the heteroecism of the rusts was generally accepted. Since that time many botanists have carried on infection experiments, so that the number of heteroecious rusts now known amounts to over 150 species.

Much has been learned of the heteroecious rusts by infection experiments carried on by European and American botanists. In America Farlow and Thaxter for eleven years

(1880-1891) studied the genus *Gymnosporangium* in this way, and Arthur began culture work in 1899 and has carried it on to the present time.

The method used in culture experiments is usually as follows. Hosts or suspected hosts are grown from seed or transplanted into pots and kept in some suitable place. Teliospores that have been wintered are germinated in a moist chamber, and the basidiospores are then applied to the leaves of the plants, which are then kept under a bell jar for a few days. If successful the pycnia usually appear in 8 to 12 days. Infection by basidiospores is usually more marked than by aeciospores or urediniospores; a rich infection usually follows and is not likely to be confused with accidental infection. The writer has obtained the best results from first placing the leaves or parts bearing telia in a moist chamber till the teliospores had germinated, usually twelve or fifteen hours. These were then suspended above the suspected aecial hosts so that the basidiospores would fall on the leaves, the whole was then covered with a bell jar for a day or two.

The easiest and most successful way to obtain clues to the alternate hosts is to watch for the appearance of aecia in the spring and early summer. If they are found thickly covering the leaves or parts of a plant, usually search in the immediate vicinity will reveal plants bearing telia, and if the teliospores are or have germinated, it will be evidence that the aecia and telia are probably connected, especially if no other rust can be found near. These clues can be tested at once by cultures if viable material can be found; if not, the test can be made in the following season, when it may be easier to collect viable teliospores.

Association of Spore Forms.

As has already been stated, the spore forms appear in a definite order. Thus, when the cycle of development is complete, the germinating teliospores give rise to the basidiospores,

the mycelium produced by basidiospore infection develops pycnia followed by aecia, later the urediniospores appear, and finally the teliospores. Any of these forms may be omitted except the teliospores and basidiospores. The Roman numerals I, II, III, are used to represent, respectively, the aecia, uredinia and telia, and a cipher is used for the pycnia. The order of development and the suppression of the spore forms may be represented as follows:

Complete series, 0, I, II, III.

Uredinia wanting, 0, I, —, III.

Aecia wanting, 0, —, II, III.

Aecia and uredinia wanting, 0, —, —, III.

Not enough attention has been given to the presence or absence of the pycnia to be sure of the number of series, but it is probable that there is also the following series:

Pycnia and aecia wanting, —, —, II, III.

Pycnia, aecia and uredinia wanting, —, —, —, III.

Schroeter has proposed names for the different types of association of spore forms. Taking the genus *Puccinia* for example, and it may be used for other genera as well, the types would be as follows:

Eu-puccinia, complete series, 0, I, II, III.

Pucciniopsis, uredinia omitted, 0, I, —, III.

Brachy-puccinia, pycnia and aecia wanting, —, —, II, III.

Micro-puccinia, pycnia, aecia and uredinia wanting, —, —, —, III. (Teliospores germinating only after a period of rest).

Lepto-puccinia, pycnia, aecia and uredinia wanting, —, —, —, III. (Teliospores germinating immediately).

Duggar suggests terms applicable to all genera having similar spore forms, and at the same time expressing heteroecism and autoecism. He employs the word *uredo* as the common root in combination with the prefixes used by Schroeter. Thus a form that is eu-heteroecious will be termed

euheteruredo; a eu-autoecious, *euautouredo*; an opsis-heteroecious, *opsishéteruredo,* and the other combinations in a similar manner.

As the terminology of the spore structures in this paper is that proposed by Arthur, his definitions of the terms are quoted (Bot. Gax. 39: 221. 1905):

"The terms I have to propose apply to the sorus. By sorus is meant the structure which arises from a single fertile hyphal mass or hymenium, either with or without a peridium, now usually called spermagonium, aecidium, uredosorus, teleutosorus and kindred names. A simple sorus includes the peridium and all true paraphyses whether peripheral or discal.

"The new terms consist of four words, with their derivatives, one for each of the four stages of uredineal fungi. For the initial stage, usually designated by a cipher and called spermagonium, pycnidium, etc., I propose *pycnium*: derivatives pycnial, pycniospores, etc. For the sorus of the first spore-stage usually designated by the Roman numeral I, and called aecidium, roestelia, peridermium, etc., I propose *aecium*: derivatives aecial, aeciospore, etc. For the sorus of the second spore-stage, usually designated by the Roman numeral II, and called uredosorus, etc., I propose *uredinium* (uredo): derivatives uredinal, urediniospores or if preferred uredospore, etc. For the sorus of the third spore-stage, usually designated by the Roman numeral III, and called teleutosorus, I propose *telium*: derivatives telial, teliospores, etc."

Specilization.

Species have been based largely on morphological characters. Infection experiments have led to a new conception of species, based on the ability of the fungi to infect hosts. Thus it has been found that some rusts morphologically alike show differences in infecting power. On the other hand it has been found that rusts which show differences in the choice of

hosts are morphologically unlike, although the fact was not noticed until attention was called to it in this way.

By infection experiments it has been shown that *Puccinia coronata,* which was previously regarded as one rust, can be broken up into two species, one producing aecia on *Rhamnus frangula* and the other on *Rhamnus cathartica.* Again the latter, *Puccinia Lolii,* may be broken up into specialized forms based on their infecting power. This rust occurs both on oats (*Avena sativa*) and on grass, *Festuca elatior;* but spores from *Avena* will not infect *Festuca,* nor spores from *Festuca* infect *Avena.* In the same way the spores of *P. graminis* from oats will not infect rye nor the reverse, although the spores produced from the germinating teliospores of both will infect the barberry. The aecia produced on the barberry from the specialized form on rye will not infect oats nor the aecia from the form on oats infect rye. The forms remain true although no morphological differences exist. In some cases, however, the forms do not seem fixed and the aecial host acts as a bridge, the aeciospores from either form infecting both host plants. Different names are given to these forms: biological species, physiological species, sister species and specialized forms, are some of the terms used. If the aecial stage occurs on different plants, even if no morphological differences exist, the rusts are usually regarded as separate species; but if the aecia are produced on the same plant, and differences of infecting power exist, they are regarded as specialized forms or form species.

Sexuality.

Sapin-Trouffy showed that in the promycelium, sporidia and aecial mycelium to the base of the aecium, each cell contains but one nucleus, while in the aeciospores and the succeeding spores and mycelium each cell contains two. These fuse in the teliospore and he regards this fusion as a true sexual process.

Blackman found that the aecial stroma formed beneath the epidermis consisted of small cells about three cells deep. The upper cells divide by walls parallel with the leaf surface. The upper cells thus formed are sterile. The lower cells formed by this division are fertile and have a large nucleus. Each cell elongates and soon two nuclei are seen in the cell, one of these having migrated into the fertile cell from the mycelial cell directly beneath or at the side of the base. A minute preforation is made in the wall and the nucleus migrates through. These nuclei divide side by side forming four nuclei, a wall separates the pair and the end cell forms the first spore. Conjugate division continues in such a way as to form a long row of cells each having two nuclei. Each cell does not at once form a spore but conjugate division of the nucleus takes place again, and a small cell is cut off from below, thus forming the spore and the intercalary cell. This migration and association of the nuclei is regarded as sexual fusion. This marks the beginning of the binucleated condition of the sporophyte generation. The unnucleated stage, on the other hand, from the basidiospores up to the base of the aecium, constitutes the gametophyte generation. Blackman regards the process as of the oosporic type—"a female cell is fertilized by the nucleus of an ordinary vegetative cell."

Blackman regards the sterile apical of the female gamete as homologous with the trichogyne of some other plants, and suggests that it once pushed its way through the epidermis, and functioned as a trichogyne fusing with the spermatia. He regards the spermatia as male cells that have lost their function, a simpler "internal" fertilization having replaced the former "external" fertilization.

Christman described a process of fertilization by the fusion of two cells, but the two cells he found to be approximately equal, so that the fusion is of the zygosporic type, the conjugation of two equal gametes.

Olive (Annals of Botany, 22: 331-360. 1908) confirms the work of Christman and Blackman and brings some of their apparently conflicting results into harmony, but on the whole confirming Christman's conclusion.

In general the nuclear life history of a species showing all the spore types is as follows: The mycelium which produces the pycnia and the aecia is uninucleate, as well as the pycniospores. There is a fusion of cells in the aecia and the aeciospores and the mycelium that produces the urediniospores, and these spores themselves are bi-nucleate. Fusion of the nuclei takes place in the teliospores, so that the basidiospores are uninucleate.

Spread of Rusts.

The question of how the rusts are spread and continued from season to season is an important one in the case of the grain rusts. *Puccinia gramimis, P. Lolii* and other destructive grain rusts are heteroecious with hibernating teliospores, but as has often been shown the aecial host is not sufficiently distributed to explain the regular and general appearance of these rusts; in fact the general impression is that the barberry has little to do with the spread of the grain rusts. Where the winter is not too severe probably the rusts are continued from year to year by hibernating uredospores and mycelium. Carleton (Bull. 16, Div. Phy. and Path. U. S. Dept. Agr., 1899) shows that several rusts winter over in the uredinial stage. Bolley states definitely that in some cases the uredospores may hibernate even in North Dakota and thus propagate the rust. Investigation tends to show that uredospores may winter and this favours the theory that spring infection comes from this source.

Another view is that the urediniospores are blown from more southern localities, where the winters are mild, and probably this has much to do with severe outbreaks. The large acreage of grains in all parts of the world and the known fact that in dust storms particles of dust are carried long

distances make this view probable. Klebahn placed wads of cotton batting in high exposed places and found thousands of rust spores in these traps. He concludes that this is the most probable method of rust distribution and accounts for the reappearance in northern latitudes. Ericksson claims that the grain seeds contain the rust in the form of "Mycoplasma," an intimate mixture of the protoplasm of the fungus with that of the host, and that under favourable conditions the mycoplasma separates and developes the normal mycelium of the rust. This would account for the reappearance of the rusts and the sudden outbreaks. He claims to have found the "corpuscles" or first visible signs of the "mycoplasm" separating from the normal cell protoplasm, but Ward has shown these to be haustoria. There is not sufficient evidence to support the theory, which has received much attention owing to the valuable work done by Eriksson in his study of the grain rusts.

Rust Enemies.

A parasitic fungus, *Darluca filum* Cast., is often present on the uredinia or telia. I have found it very common on all the rusts infecting *Juncus,* and also on many of the sedge and grass rusts. In some cases it was difficult to obtain teliospores owing to its attack. I have also found it very plentiful on the uredinia of *Coleosporium Solidaginis* and *Phragmidium Potentillae-canadensis.* This parasite can be recognized by the small, black pycnidia, which are filled with colourless, fusiform two-celled spores. The pycnidia are usually on the uredinia and occasionally on the telia and aecia. The parasite is doubtless an important factor in checking the spread of rusts.

Another parasite, a species of *Tuberculina,* was found attacking the aecial stage of *Gymnoconia interstitialis,* but it did not seem to be generally distributed.

The larvae of a species of *Cecidomyia* is very commonly present feeding on the aeciospores of many species. These

probably tend to reduce the fungus by devouring the spores, but they may aid in their distribution by spreading them as they crawl about.

Economic Aspects of the Rusts.

The rusts are true parasites and unable to live except in the tissues of their hosts. They attack many valuable trees and shrubs as well as field and garden crops, and, as they live at the expense of their hosts, often cause serious damage. They cannot be combatted with much success by spraying with the Bordeaux or other mixtures. Usually a knowledge of their life history will alone suggest some method of holding them in check.

Rusts of the Conifers: Many rusts of the genus *Coleosporium* and *Cronartium* have their aecial stages on some species of pine, but no rusts were found on the pine in Nova Scotia and none are likely to occur, unless the European currant rust (*Cronartium rubicola*) should be introduced. The aecial stage is found on the white pine (*Pinus strobus*) and is said to be very destructive in Europe. The uredinial and telial stages on currant bushes does not seem to be of much importance. An outbreak occurred at Geneva, N. Y., in 1906, and in 1909 pine seedlings which were imported from Germany and were distributed through the north eastern United States and Canada were found to be diseased. The only way to control the fungus would seem to be to destroy the wild species of *Ribes* in the neighbourhood of the pine forest areas.

The leaves of the balsam fir (*Abies balsamea*) are attacked by the aecial stage of the blueberry rust (*Calyptospora columnaris*) by *Peridermium balsameum* and by a *Caeoma*. The spores are formed on the under side of the leaves which turn yellowish. *Peridermium elatinum*, the aecial stage of *Melampsorella elatina*, forms the rather conspicuous witches' brooms on the same host. These may be removed in the spring

before the spores are shed and burned. However, little injury is done by these fungi and no measures of control are necessary.

Peridermium Peckii and *Caeoma Abietis-canadensis* Farl. occur on the leaves of the hemlock (*Tsuga canadensis*), but they are not very common nor of much importance. *Necium Farlowii,* which attacks the leaves and young twigs, is more injurious. The infected twigs soon curl up and die, but the fungus is rare and therefore of little importance.

The leaves of the spruces (*Picea*) are attacked by the aecial stages of the *Ledum* rusts (*Melampsoropsis ledicola, M. abietina*) and though sometimes they are very richly infected yet no serious injury seems to be done. The destruction of the *Ledum* plants in the neighbourhood of the spruces would probably be effective in controlling these rusts. The spruce cones are also attacked by the aecial stage of the *Pyrola* rust (*Melampsoropsis Pyrolae*).

The aecial stages of the willow and poplar rusts (*Melampsora Bigelowii, M. Medusae*) are found on the larch (*Larix laricina*) but they are rare and of no economic importance.

Rusts of Deciduous Trees: The leaves of the poplars and willows are attacked by the uredinial and telial stages of *Melampsora Medusae* and *M. Bigelowii* respectively, and those of the birches by *Melampsoridium Betulae,* but the injury is not serious and does not usually call for control. The burning of the infected leaves in the fall would probably be helpful in checking the rusts.

The aecial stage of some rust of the genus *Gymnosporangium* has been collected on the fruit of the wild plum (*Amelanchier*), and probably the alternate host is the low juniper. It is probably rare and of little importance. In the United States the aecial stages of some species of the genus *Gymnosporangium* attack the leaves of the cultivated apple, but these have not been reported from Nova Scotia.

Rusts of Shrubs: The rusts of the genus *Phragmidium* attack the wild roses freely and may attack the cultivated

species, but no injury to the latter plants has been reported from Nova Scotia. Control measures would be the destruction of the affected parts in the fall before the dispersal of the spores.

The "Orange Rust" of the raspberry and blackberry (*Gymnoconia interstitialis*) is a serious pest in some parts of the United States, attacking the cultivated species. As far as reported it is confined to wild species in Nova Scotia. The mycelium is perennial so that to combat this rust the diseased plants should be dug up and burned.

The aecial stage of a sedge rust sometimes occurs on the fruit of the cultivated gooseberry. This stage usually passes under the name of *Aecidium grossulariae*. It is probably not common enough to call for control measures, which would be the destruction of the sedges in the vicinity.

Rusts of the Cereals: A few collections of corn rust have been made, but it is not usually common enough to cause any serious injury and has not received much attention.

The black or stem rust (*Puccinia graminis*) attacks wheat, oats, barley, rye and many grasses. It has a world wide distribution and does immense damage to the grain crops.

It does not seem to be very common about Pictou, but in some parts of the province it is abundant and must cause much injury to the oat and wheat crop. It can be recognized by the black uncovered telia which are usually found on the stem, though they may occur on the leaves and sheaths.

The aecial stage is on the barberry, but this shrub is not common enough to explain its appearance year after year. It is probable that the barberry has little to do with the rust in Nova Scotia, and that the aecial stage is usually omitted. The uredospores live for some time and have been shown to survive the winter even in cold climates. Another theory is that the uredospores are carried from more southern countries, where they survive the winter, by the wind, and thus the spring

infection takes place. Many grasses are attacked by this rust, and some observers have thought that the mycelium may survive the winter in these grasses, and that infection of the grain crops may come from this source in the spring when uredospores are produced. However, artificial infection experiments indicate that few of the grass rusts will grow on wheat or other grains. The rusts on the various species have become adapted to their particular host and will not usually grow on other species.

Little can be done to combat this rust. Varieties that ripen early are not usually so badly affected, so early sowing and the sowing of early varieties would be advantageous. Some varieties are more susceptible than others and attention is now being given by plant breeders to the production of rust proof varieties. It is probable that much may yet be accomplished along this line. The barberry which is sometimes grown in hedges should be destroyed as it probably forms a bridging host between the various specialized forms on the grasses.

The crown rust of oats (*Puccinia Lolii*) is very common on the oat about Pictou and must do much injury to the crop. It is found only on the oat and can be easily distinguished from the stem rust, as the telia remain covered by the epidermis and occur only on the leaves and sheaths. The aecial stage is found on the buckthorn, an introduced tree or shrub which is rather common along some roadsides near Pictou. This may account for the prevalence of the rust as these trees showed a rather pronounced infection in the springs of 1909-10. No control measures are known, but the destruction of the aecial host.

The brown or covered rust of wheat, *Puccinia triticina,* is quite common about Pictou. The telia are usually formed on the lower side of the leaves. They are black in color and remain covered by the epidermis. This rust usually passes in America under the name *Puccinia rubigo-vera* or *P. rubigo-vero tritici.* Its systematic position is somewhat unsettled, and its aecial stage somewhat doubtful.

The timothy rust only began to attract attention in North America a few years ago. It seems to be rapidly increasing. Some regard it as identical with the stem rust of wheat, while others regard it as a distinct species with unknown aecia. In gross and microscope appearance it cannot be distinguished from the stem rust of wheat. It is quite common on the timothy about Pictou, especially on timothy about roadsides and fences that has not been cut at the harvest season. It seems to be increasing so rapidly that there is danger that it may become a pest, but the early maturing of the hay crop may prevent any serious damage.

Red Clover Rust: The uredinial and telial stages of clover rust (*Uromyces trifolii*) is common on the leaves of clover in the fields of Pictou. They appear as brownish powdery spots on the under surface of the leaves and on the stems. The aecial stage is unknown. It is said to do little damage to the early crop, but the attack on the second crop is more severe. Control is unnecessary, and no preventative measures are known.

Classification.

The classification of the rusts presents many difficulties owing to the variable number of forms and the heteroecism of many species. Besides, rusts that cannot be distinguished morphologically have become specialized or show physiological differences in the choice of their hosts, and botanists are not agreed as to the classification of these. Some regard them as separate species, while others would place them as simply physiological species or form species. The classification is likely to remain unsettled until they are more fully studied and their life histories and relations to their hosts more completely known.

The rusts are regarded by most botanists as belonging to the class *Basidiomycetes* on account of the germinating teliospore producing four basidia which either remain within the spore cell or are borne in the air on a short promycelium, each

basidium bearing a single spore. A few botanists regard the teliospore as an ascus in which the spore-wall is united with the ascus-wall, thus the rusts would belong to the class *Ascomycetes.*

The order *Uredinales* (*Uredinae* Tul.) to which the rusts belong is divided by Dietel into four families: *Melampsoraceae, Coleosporiaceae, Cronartiaceae* and *Pucciniaceae.* The separation is based on the character of the telia and the teliospores.

In the *Melampsoraceae* the teliospores stand side by side forming one-layered, flattened masses, which are separated with difficulty; or they may be scattered in the tissues of the host, then they are usually two- or four-celled; the genus *Uredinopsis* belongs to the latter group. The teliospores are always sessile.

In the *Coleosporiaceae* the teliospores are united into one- or two-layered, light-coloured, waxy crusts. They germinate without a promycelium, the spore cell soon divides into four basidia and each of these produces a large basidiospore about 20μ long. The teliospores are sessile except in a South American genus *Chrysopsora.*

The *Cronartiaceae* have sessile teliospores which are formed in series and either separate from each other or remain united in filiform masses, as in *Cronartium,* or are formed in chains and compacted laterally forming cushion-shaped masses as in *Chrysomyxa.*

The *Pucciniaceae,* which contain the well known rusts, have stalked teliospores either fasicled or free, usually easily separable from the host plant, but sometimes, as in the genus *Gymnosporangium,* embedded in a gelatinous mass.

Arthur recognizes three families: *Coleosporiaceae, Uredinaceae* (the latter including Dietel's *Melampsoraceae* and *Cronartiaceae*), and *Aecidiaceae* corresponding to *Pucciniaceae.*

The following is a synopsis of the genera represented in north eastern North America. It is largely based on Dietel's *Uredinales* in *Die Natürlichen Pflanzenfamilien.*

MELAMPSORACEAE.

I. Teliospores mostly 2- and 4-celled, in the latter case the walls in the form of a cross.
   1. Teliospores singly in the parenchymatous tissue of the host.................*Uredinopsis.*
   2. Teliospores united in single layered crusts—
      A. Teliospores formed outside the cells of host............*Pucciniastrum.*
      B. Teliospores within cells of host—
         a. Life cycle with aecia and telia .... *Calyptospora.*
         b. Life cycle with telia, on *Tsuga* .... *Necium.*

II. Teliospores 1-celled, always united in small or large crusts.
   1. Teliospores formed outside the cells of host—
      a. Uredinia with paraphyses intermixed with spores. Aecia without a peridium ... . *Melampsora.*
      b. Uredinia and aecia with peridium. No paraphyses .... *Melampsoridium.*
   2. Teliospores formed inside of cells of host—
      a. Uredinia opening by a pore......... .... *Melampsorella.*
      b. Uredinia not opening by a pore, teliospores hyaline .... *Hyalopsora.*

COLEOSPORIACEAE.

1. Teliospores formed in a gelatinous swelling of sporophore, on *Pinus* .... *Gallowaya.*
2. Teliospores in flat crusts, uredinia in chains .... *Coleosporium.*

CRONARTIACEAE.

1. Telia cushion shaped ....*Chrysomyxa.*
2. Telia thread-like or columnar ....*Cronartium.*

PUCCINIACEAE.

I. Teliospores embedded in a gelatinous matrix, on *Coniferae* .... *Gymnosporangium.*

II. Teliospores not embedded in a gelatinous matrix, not on *Coniferae*—

  1. Teliospores one-celled .... *Uromyces.*

  2. Teliospores more than one-celled.

   A. Teliospores two-celled—

    a. Aecia without peridium .... *Gymnoconia.*

    b. Aecia with peridium....*Puccinia.*

   B. Teliospores more than two-celled—

    a. Spore cells in a row—

     (1) Teliospores colourless .... *Kuehneola.*

     (2) Teliospores coloured .... *Phragmidium.*

    b. Spore cells, three in the form of a triad ....*Triphragmium.*

All the genera included in this synopsis are represented in Nova Scotia except *Gallowaya* and *Hyalopsora.* The last one will probably yet be found.

Arthur has adopted a new system of classification of the rusts. His classification is based largely on the number of spore forms present. For example the genus *Puccinia* as now commonly known is replaced by four genera, *Dasyspora* with teliospores, *Bullaria* with urediniospores and teliospores, *Allodus* with aeciospores and teliospores, and *Dicaeoma* with all spore forms. Yet the author of the system states that "it would be a wholly false impression to assume that this character of the suppression of the spore forms is the only one separating the genus from others of the group. It is the most prominent and most easily stated, but in the most cases will be found associated with other characters of accepted

value." He adds that his classification has to do fundamentally with the progressive evolution of the rusts and not with adaptations; thus the genus *Dasyspora* includes species that have progressed in their evolution to the stage where aeciospores and urediniospores have been effectively suppressed from the life cycle. Such a classification demands a more intimate knowledge of the rusts and more insight into their life history than the old system which was based largely on the structure of the teliospores.

He also states that there are some short cuts that enable one to name his collections. "Thus, telia associated with pycnia may be safely assumed to belong to a genus in which aecia and uredinia are wanting, or at most so little developed as to be of no taxonomic importance. In like manner pycnia associated with uredinia, the so-called primary uredinia, may be assumed to indicate a genus in which aecia are wanting. If aecia show telia arising within or about them from the same mycelium, it may safely be assumed that no uredinia belong to the life cycle. Furthermore it rarely or never happens that teliospores of the *Uromyces-Puccinia* type, germinating immediately on maturity, belong to genera with other spore forms in the life cycle, excepting some largely tropical genera. Short cuts are also available in other directions. All gramineous and cyperaceous hosts bear rusts that may be assumed to possess all spore forms and are heteroecious. Only one exception is known at present."

In the following pages the species occurring in Nova Scotia are described. The classification is largely that of Dietel in "Die Natürlichen Pflanzenfamilien." While it might be better to follow Arthur's classification, as he has made the most extensive and thorough study of North American rusts, yet his work has not progressed far enough to make that possible in all cases, so for the present the classification that follows has been adopted.

A list of Nova Scotian genera follows with the number of species that have been found in each genus. The names used by Arthur in the North American Flora are enclosed in brackets where they differ from those in the classification adopted. *Melampsoropsis,* however, is used instead of *Chrysomyxa,* although Dietal adopts the latter term.

Nova Scotian Families and Genera.

Family.	Genus.		No. of Species
Coleosporiacae.	Coleosporium		1
Melampsoraceæ, (Urediniaceae).	Melampsora (Uredo)		3
	Pucciniastrum		6
	Melampsoridium		1
	Melampsorella		1
	Hyalopsora		0
	Calyptospora		1
	Necium		1
	Uredinopsis		5
Pucciniaceae, (Urediniaceae).	Melampsoropsis (Chrysomyxa)		5
	Cronartium		1
Pucciniaceae, (Aecidiaceae).	Phragmidium	Phragmidium Earlea	4
	Triphragmium		1
	Gymnoconia		1
	Kuehneola		1
	Gymnosporangium (Aecidium)		1
	Uromyces	Pileolaria Nigredo Uromycopsis Klebahnia Telospora	14
	Puccinia	Tranzschella Polythelis Dicaeoma Allodus Bullaria Dasypora	45

The descriptions that follow are based on the collections of Nova Scotia material. It was necessary when certain forms were not collected or when the collections were scanty to make use of the systematic literature cited at the end of this paper. These cases are recorded in the notes that follow the description of the species.

An interesting feature of the work was the field study with the object of connecting aecial and telial stages and the culture experiments undertaken to test the clues thus obtained. As a result the life histories of a number of species previously unknown were worked out. These are noted under the descriptions of the species.

A 50% solution of lactic acid was used for the purpose of clearing the sections and swelling the spores to their normal shape and size. This is necessary in the case of the spores of the *Puccinia Hieracii* type, as the dried spores are much contracted and wrinkled. The spores or sections were placed on a slide and a drop of the lactic acid solution added. The slide was then heated over a spirit lamp and the liquid was brought to the boiling point or allowed to boil for a few seconds. This also brought out the germ pores more clearly.

The drawings are made with the aid of a camera lucida to a uniform magnification of 480 diameters, except in a few cases noted in the descriptions accompanying the drawings which are reduced to one-half the diameters in the photogravure process.

Gray's "New Manual of Botany" was used in determining the host plants.

The writer is deeply indebted to Dr. J. C. Arthur for valuable suggestions and for the determination of doubtful species. He is also indebted to John Macoun, Naturalist, Geol. Survey Dept. of Canada, for the prompt determination of a few doubtful host plants.

THE RUSTS OF NOVA SCOTIA.

Family 1. COLEOSPORIACEAE.

Basidia internal, i. e. each original cell soon divides into four superimposed divisions (the basidia), each of these germinates by a single sterigma bearing a large basidiospore. Telia waxy. Teliospores compacted laterally into layers, sessile (in all North American species); walls weakly gelatinous.

This family is represented in North America by one genus, *Coleosporium,* or according to Arthur's classification by two genera, *Coleosporium* and *Gallowaya,* the life cycle of the latter having only telia. The family is represented in Nova Scotia by only one species, and no more are likely to occur as all the other species thus far reported in North America are of a more southern range. It is possible that *C. Campanulae* (Pers.) Lév., which has been collected in Vermont may yet be found to occur.

COLEOSPORIUM Lév.

Pycnia flattish, without ostiolar filaments. Aecia with large peridium. Aeciospores having colourless wall with dense deciduous tubercles. Uredinia without peridium. Urediniospores catenulate; wall colourless, verrucose, pores obscure. Telia waxy, usually roundish. Teliospores sessile, one-celled, (appearing four-celled owing to early division of contents); wall smooth, colourless, thickened and gelatinous at the apex.

Coleosporium Solidaginis (Schw.) Thuem.

0 & I. On *Pinus rigida* Mill. *Peridermium acicolum* Und. & Earle.

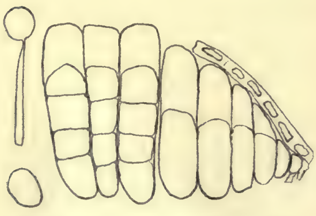
II. Uredinia mostly hypophyllous, sometimes caulicolous, scattered or sometimes gregarious, small, soon naked.

pulverulent, yellow or orange-yellow, ruptured epidermis rather inconspicuous. Urediniospores globoid or ellopsoid, 16-22 by 19-35μ; wall rather thin, strongly verrucose; contents orange-yellow, slowing fading to colourless.

III. Telia hypophyllous, scattered or crowded and confluent, roundish or irregular, slightly elevated, small reddish-orange. Teliospores terete, 18-25 by 54-85μ, round or obtuse at both ends, wall swelling above 30-40μ; contents orange-yellow; basidiospores globoid or ellipsoid, about 12 by 18μ, yellowish.

Uredinia and telia on *Solidago* and *Aster* species, Pictou, Truro, etc. The following hosts were determined: *Solidago bicolor* L., *S. rugosa* Mill., *S. canadensis* L., *Aster cordifolius* L., *A. umbellatus* Mill., *A. lateriflorus* (L.) Britton.

The uredinial and telial stages of this rust are very common on the various species of *Solidago* and *Aster* near Pictou, and probably throughout the Province. The aecial stage is found on *Pinus rigida* Mill. and in North America is known only from a small area from Massachusetts to southern New Jersey. (Arthur & Kern, Bull. Torr. Bot. Club, 33: 413. 1906).



1. Section of telium of *Coleosporium Solidaginis.*

Since the aecial stage (*Peridemium acicolum* Und. & Earle) appears to be limited to a small region along the Atlantic coast, and the other stages are common almost throughout the United States and Canada, the question arises how it passes the winter. Clinton carried out some experiments that would tend to show that the mycelium was not perennial in the rootstocks (Conn. Exper. Sta. Report 378, 1907). He believes that the mycelium of the fungus is carried over the winter in the basal rosettes of young leaves which may survive the winter.

Family 2. MELAMPSORACEAE.

Basidia external, i. e. germination with a typical promycelium with small spherical sporidia. Telia in more or less definite single layered crusts. Teliospores compacted laterally into layers, or rarely solitary within the tissues (Uredinopsis), sessile; wall usually firm, rarely with an outer gelatinous layer.

This family is represented in north-eastern North America by eight genera, and of these seven occur in Nova Scotia. The remaining genus *Hyalopsora,* which is confined to ferns, probably occurs, as *H. Aspidiotus* (Peck) Magn. on *Phegopteris Dryopteris* (L.) Fée has been reported from New Hampshire, and *H. Polypodii* on *Cystopteris fragilis* Bernh. from New York.

MELAMPSORA Cast.

Pycnia conoidal or hemispheric without ostiolar filaments, hymenium flattish. Aecia without peridium or paraphyses. Uredinia without peridium. Urediniospores borne singly on pedicels; wall colourless, verrucose; capitate paraphyses intermixed with the spores. Telia indehiscent in waxy layers or crusts. Teliospores one-celled, closely compacted into a single layer, prismatic or ellipsoid; wall smooth, coloured.

Both heteroecious and autoecious species belong to this genus, the former only have been found in Nova Scotia. *Melampsora lini* (Pers.) Tul. is an autoecious species which is destructive to flax in the United States.

Melampsora Bigelowii Thuem.

Uredo Bigelowii (Thuem.) Arth.

0. Pycnia chiefly epiphyllous, scattered, minute, punctiform, pale yellow, inconspicuous.

I. Aecia chiefly hypophyllous, scattered or somewhat gregarious, on whitish areas occupying part of the leaf, small, round or mostly oblong, pale yellow fading to colourless, soon

naked, pulverulent, ruptured epidermis evident. Aeciospores mostly globoid, about 18-24μ; wall colourless, thick, minutely verrucose.

II. Uredinia hypophyllous, on conspicuous yellow spots, usually gregarious, round, oval or irregular .3-.6mm. across, sometimes confluent, ruptured epidermis inconspicuous, soon naked, somewhat pulverulent. Urediniospores globoid or ellipsoid, 15-19 by 18-27μ, wall colourless, thick, evenly verrucose, pores scattered; paraphyses mixed with the spores, capitate, smooth, 50-80μ long, heads 19-24μ broad, wall thick, 3-5.5μ.

III. Telia amphigenous, sometimes mostly hypophyllous, scattered, often abundant and occupying most of the leaf surface, roundish or irregular, often confluent, sometimes elevated, orange-yellow, becoming yellowish or purplish-brown, subepidermal, teliospores prismatic, sometimes oblong, 12-15 by 33-44μ, rounded at both ends or truncate; wall cinnamon-brown, smooth, uniformly thin or sometimes thickened above.

Pycnia and aecia on *Larix laricina* (DuRoi) Koch, Pictou.

Uredinia and telia on *Salix rostrata* Richards., and other *Salix* species, Pictou, Truro, Oakfield.

Collections of aecia on *Larix laricina* were made on June 24, 1910, and during the following week. The aecia were found to be widely distributed in the vicinity of Pictou, so that almost every tree of *Larix* examined showed at least a few infected leaves. In June, 1912, aecia were found to be very abundant in one region near Pictou, the young *Larix* trees appearing yellow at a considerable distance. It was impossible to determine whether the aecia belonged to this species or to *M. Medusae* as there is no morphological differences. It seems probable, however, that these collection belong to this species as cultures by the writer showed that the poplar rust in this region has aecia on *Tsuga canadensis*.

Melampsora Medusae Thuem.

0. Pycnia amphigenous, mostly hypophyllous.

I. Aecia hypophyllous, often on the young twigs causing deformation, elongate or rounded, ruptured epidermis inconspicuous, pale yellow fading to white. Aeciospores globoid, about 16-20μ; wall colourless, thick, minutely verrucose.

II. Uredinia amphigenous or mostly hypophyllous, often on yellowish spots, scattered, roundish, very small, soon naked, somewhat pulverulent, orange-yellow, fading to pale yellow. Urediniospores ellipsoid or obovate-ellipsoid, **16-17** by 22-27μ, wall colourless, rather thick, sparsely but rather strongly verrucose; paraphyses numerous, capitate, thick walled, intermixed with the spores. (Urediniospores often flattened laterally with flattened sides smooth).

III. Telia amphigenous, usually only hypophyllous, scattered or confluent, irregularly roundish, small, slightly elevated, reddish-brown, becoming dark chocolate-brown, subepidermal. Teliospores prismatic, 10-16 by 27-46μ; wall smooth, light brown, uniformly thin.

Pycnia and aecia on leaves and cones of *Tsuga canadensis* (L.) Carr., Pictou, Truro.

Uredinia and telia on *Populus grandidentata* Michx., Pictou, New Glasgow, Truro; *P. tremuloides* Michx., Pictou.

The writer has shown by cultures that this species has in this region its aecia on *Tsuga-candensis*. (See Mycologia 4: 188. 1912). The aecial stage is *Caeoma Abietis-canadensis* Farl., which is rather common on its host. Arthur has shown by cultures that the aecial stage also occurs on *Larix* (Jour. Mycol. 10: 13. 1904; 11: 52. 1905; 12: 13. 1906). It is probable that there are two races of the same species, that in the east having aecia on *Tsuga* and in the west on *Larix*.

2. Surface view of part of telium of *Melampsora Medusae*. Side view.

The telial stage is rather common on the large-toothed aspen about Pictou. It is rather rare on the more common poplar, (*Populus tremuloides* Michx.). The uredinial stage is not conspicuous but leaves, when the telial stage appears in the fall, soon turn black and are then quite conspicuous.

Melampsora arctica Rostr.

Uredo Rostrupiana Arth.

0. Pycnia amphigenous, chiefly hypophyllous, punctiform, inconspicuous, honey-yellow.

I. Aecia hypophyllous, arranged in two rows, roundish, oval or oblong, pale orange-yellow, fading to colourless, soon naked, pulverulent, ruptured epidermis evident, .2-.3 by .3-.7 mm. Aeciospores globoid, about 16-21μ in diameter; wall thick, colourless, verrucose, contents pale yellow.

II. Uredinia chiefly hypophyllous, scattered, round, very small, orange-yellow fading to pale yellow, somewhat pulverulent, ruptured epidermis inconspicuous. Urediniospores ellipsoid or obovate, small, 14-16 by 16-20μ; wall colourless, thin, uniformly and closely verrucose; paraphyses mixed with the spores, smooth, about 50μ long with heads about 22μ broad, wall thickened above.

III. Telia mostly hypophyllous, rounded or irregular, scattered or often confluent, slightly elevated, reddish brown, becoming dull brown, subepidermal. Teliospores prismatic or oblong, 8-10 by 22-32μ; wall smooth, pale brown, thin.

Pycnia and aecia on *Abies balsamea* (L.) Mill., Pictou.

Uredinia and telia on *Salix discolor* Muhl., and *S. rostrata* Richards, Pictou.

This rust can be distinguished from *M. Bigelowii* by the small and thin walled urediniospores. It is common in the vicinity of Pictou. Cultures by the writer during the spring of 1912 showed that the aecial stage is on *Abies balsamea*. (See Mycologia 4: 187. 1912).

MELAMSORIDIUM Kleb.

Uredinia with a firm peridium dehiscing by a central pore, cells of the orifice sharp pointed. Urediniospores borne singly on pedicels. Telia indehiscent, forming evident layers beneath the epidermis. Teliospores oblong or prismatic, one-celled.

The genus includes three species on *Betulaceae*. Arthur in the North American Flora reports from North America only the species described below.

Melampsoridium betulinum (Pers.) Kleb.

Melampsoridium Betulae (Schum.) Arth.

0 & I. On *Larix decidua* Mill. (Europe). Not yet collected in North America.

II. Uredinia hypophyllous, on small yellow spots, scattered, small, round, reddish-yellow, at length pulverulent; peridium hemispherical, firm, opening by a central pore, cells polygonal, with pointed cells at the orifice, points 10-14μ long. Urediniospores elongate-elliptical or elongate-obovate, 10-16 by 25-40μ; wall colourless, thin, strongly and sparsely echinulate except smooth apex.

III. Telia hypophyllous, small, often thickly covering the surface of the leaf, at first waxy yellow, becoming brown and finally blackish, indehiscent. Teliospores prismatic in a palisade like layer beneath the epidermis, 7-16 by 30-50μ, somewhat rounded at each end; wall nearly colourless, thin, slightly thicker at the apex, smooth.

Uredinia and telia on *Betula populifolia* Marsh, *B. lutea* Michx., Pictou.

The uredinial stage of this species was common on *Betula populifolia* about Pictou during the fall of 1909. It is conspicuous as the leaves are thickly covered with small yellow spots and usually a number of leaves near together are infected.

It was less common during the fall of 1910, only one collection being made. The telial stage was not found although collections were made at various intervals during the fall and early winter. The aecial stage, *Peridermium Laricis* (Kleb.) Arth. & Kern, has not been collected in North America.

MELAMPSORELLA Schroet.

Aecia with peridium. Aeciospores with verrucose walls. Uredinia with peridium. Telia effused, indehiscent. Teliospores within the epidermal cells, one-celled; wall smooth, colourless.

But one species of this genus is found in North America. Some of the species which Dietel places in this genus are assigned to *Hyalopsora* by Arthur.

Melampsorella Cerastii (Pers.) Schroet.

Melampsorella elatina (Alb. & Schw.) Arth.

0. Pycnia epiphyllous, few, scattered, punctiform, inconspicuous.

I. Aecia from a perennial mycelium forming witches' brooms; hypophyllous, in two rows, dropping out of leaf at maturity, mostly irregularly oblong or roundish, rather large; peridium colourless, soon falling away and exposing spores. Aeciospores sub-globoid or ellipsoid, 15-22 by 19-27μ; wall colourless, thin, closely verrucose.

II. Uredinia amphigenous, scattered or grouped, small, round, .1-.4 mm. across, orange-red when fresh, pale yellow when dry; peridium hemispherical, dehiscent by a small central orifice. Urediniospores ellipsoid or obovoid, 12-18 by 16-30μ; walls pale yellow, rather thin, sparsely echinulate.

III. Telia hypophyllous, on whitish or pale reddish spots. Teliospores within the epidermal cells, one-celled, short-cylindrical or polygonal, 13-20μ broad; wall colourless, smooth, thin.

Aecia on *Abies balasmea* (L.) Mill., Pictou, July 10, 1909. Uredinia and telia on *Stellaria* and *Cerastium* (Europe and United States).

The aecial stage, *Peridermium elatinum* (A. & S.) Kunze & Schmidt, is common and widely distributed. It produces the conspicuous witches' brooms so common on the balsam fir.

Klebahn and Fischer have proved by numerous cultures the connection of the aecial stage on *Abies* and the stages on *Alsine, Stellaria* and *Cerastium.* The uredinial and telial forms are very inconspicuous, but they have been collected a few times in North America, mostly in the western United States.

PUCCINIASTRUM Otth.

Uredinia barely protruding through the epidermis; peridium present, opening by a central pore. Urediniospores borne singly on pedicels with colourless walls, pores not evident.

Telia forming layers in the epidermal cells or immediately beneath the epidermis. Teliospores oblong or prismatic, two to four-celled by vertical or oblique walls in two planes.

Nine species of this genus are found in North America. Six are here described from Nova Scotia. Another species, *P. sparsum* (Winter) Ed. Fisch., may occur on *Arctostaphylos alpina* (L.) Spreng., as it has been collected in Quebec.

Pucciniastrum pustulatum (Pers.) Diet.

0. Pycnia hypophyllous, abundant, inconspicuous.

1. Aecia hypophyllous, mostly in two rows, cylindrical, about 1 mm. high. Aeciospores ovoid or irregularly globoid, 10-20 by 16-22μ; wall colourless, finely verrucose, rather thick, contents orange-yellow.

II. Uredinia hypophyllous and fruiticolous, scattered or in small groups, not discolouring the leaf, small, bullate, round, dehiscent by a central pore, orange fading to pale yellow, long covered by the arched epidermis; peridium hemispherical, delicate, cells cuboidal, wall smooth. Urediniospores obovate

or oval, sometimes globose, 11-16 by 15-24μ; wall colourless, thin, finely echinulate; contents orange-yellow when fresh.

III. Telia hypophyllous, indehiscent, flat, small, scattered or often gregarious and confluent, reddish-brown, becoming blackish-brown. Teliospores usually in one layer, oblong or angular by pressure, about 18-30μ high by 16-27μ wide; walls pale brown, smooth, thin, thicker at the apex.

Pycnia and aecia on *Abies balsamea* (L.) Mill., Pictou, June, 1911.

Uredinia and telia on *Epilobium angustifolium* L., *E. Hornmanni* Reichenb., Pictou; *E. adenocaulon* Haussk., Truro.

Arthur gives the measurement of the teliospores as 10-14 by 17-35μ. This species is very common on its hosts especially on *Epilobium angustifolium.* The leaves become discoloured when the telia are well formed, and usually soon die.

The life history of this species in North America was worked out by the writer. (Mycologia 4: 176. 1912). It had been previously established in Europe, the aecia occurring there on *Ribes pectinata* DC. The aecia of this rust have not yet been recognized elsewhere in North America.

Pucciniastrum arcticum (Lagerh.) Tranz.

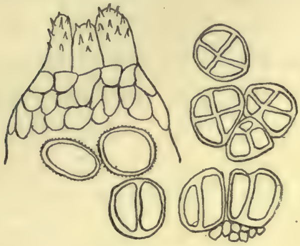
0 & I. Pycnia and aecia unknown.

II. Uredinia hypophyllous, usually thickly scattered over extended areas, round, small, orange-yellow, fading to pale yellow, dehiscent by a central pore, somewhat pulverulent; peridium firm, ostiolar cells coarsely echinulate above. Urediniospores obovate or ellipsoid, 13-15 by 16-25μ; wall colourless, thin, distinctly echinulate with low points.

III. Telia hypophyllous, brownish, small, flat, inconspicuous. Teliospores intercellular, globoid or cuboid, about 19-24μ in diameter; wall smooth, light brown.

On *Rubus triflorus* Richards, Truro, Pictou; *Rubus idaeus* Var. *aculeatissimus,* (*Rubus strigosus* Michx.), Pictou, New Glasgow.

The uredinial stage is very common on the raspberry. It is not conspicuous, but can be easily recognized by examining the under side of the leaf. The telial stage is difficult to distinguish, but late collections of leaves affected by the uredinal form usually show abundant telia, when sectioned and examined with the microscope.



3. Partial section of aecidium of *Pucciniastum arcticum*. Surface and side view of teliospores.

Arthur in the "North American Flora" reports this species only from Alaska on *Rubus stellatus*. Farlow (Rhodora 10: 13. 1908) mentions a specimen of typical *P. arcticum* on *Rubus triflorus* from Grand Manan, N. B. He also describes a *Pucciniastrum* found on *Rubus neglectus* and *Rubus strigosus* in the north-eastern United States, and regards it as a variety of *P. arcticum* differing from the type in the markedly conical shape of the peridium and prominent spines. To distinguish it he gives it the name *P. arcticum* (Lagerh.) Tranz., Var. *americanum* Farlow. If this separation holds good the collection on *Rubus triflorus* belongs to the species and that on *Rubus idaeus* Var. *aculeatissimus* to the variety.

Pucciniastrum Myrtilli (Schum.) Arth.

Pucciniastrum Vacciniorum Diet.

0 & I. Pycnia and aecia on *Tsuga canadensis*.

II. Uredinia hypophyllous, scattered or somewhat gregarious, small, bullate, round, long covered by the overarching epidermis; peridium hemispherical, cells small, cuboidal. Urediniospores obovate or ellipsoid, 13-16 by 16-24μ; wall colourless, minutely and sparingly echinulate; contents orange-yellow.

III. Telia chiefly epiphyllous. Teliospores in the epidermal cells, ellipsoid or globoid, 18-23 by 20-30μ; wall smooth, thin.

On *Vaccinium Pennsylvanicum* Lam., Pictou, Oct. 4, 1910.

Arthur in the "North American Flora" describes the telia as hypophyllous, and the teliospores as oblong or columnar and 7-10 by 14-17μ. There is a marked difference in the position of the telia and the size and shape of the teliospores of my collections from this description. The uredinia agree with Arthur's description.

The rust is inconspicuous and, though only a few collections were made, it will probably be found to be common.

The aecial stage of this rust is doubtless the *Peridermium* so common on *Tsuga canadensis* which has been confused with *Peridermium Peckii.* Clinton (Report Conn. Agric. Exper. Station for 1909-1910, page 719) has connected this rust with *Peridermium Peckii,* but it is probable his aecia are the most common form which have been confused with the true *Peckii.* The aecia, which doubtless belong to this species, were found to be very common at Truro, Oakfield and Pictou, and the field evidence was very strong that they were connected with this rust. Collections sent to Dr. Arthur were regarded as distinct from *Per. Peckii.*

Pucciniastrum Pyrolae (Pers.) Diet.

0 & I. Pycnia and aecia unknown.

II. Uredinia amphigenous, on small reddish spots, small, scattered or grouped, mammillose, yellowish-red, dehiscent by a central pore, long covered by the overarching epidermis; peridium hemispherical, cells elongated vertically below, ostiolar cells large, echinulate. Urediniospores oblong or ellipsoid, 13-16 by 24-35μ; wall colourless, rather thick, minutely and sparsely echinulate; contents orange-yellow when fresh.

III. Telia hypophyllous, adjoining uredinia, inconspicuous, subepidermal, an even layer of laterally flattened cells. Teliospores oblong or columnar, 10-12 by 24-28μ; wall uniformly thin, colourless.

On *Pyrola elliptica* Nutt., Pictou, Oct. 4, 1910.

Only the uredinial stage was collected. The species does not seem to be common.

Pucciniastrum minimum (Schw.) Arthur.

0. Pycnia hypophyllous, rarely epiphyllous, numerous, scattered, inconspicuous.

I. Aecia hypophyllous in two rows, occupying part or usually all of the leaf, cylindrical, small, about .5-1 mm. high; peridium colorless, dehiscing at the apex, cells joined loosely, slender. Aeciospores broadly ellipsoid, 13-17 by 19-27μ; wall colourless, rather thin, finely and evenly verrucose.

II. Uredinia hypophyllous, small, scattered or chiefly grouped on indefinite discoloured areas, mammillose, pale yellow, dehiscent by a central pore, finally pulverulent, long covered by the overarching epidermis; peridium hemispherical, cells small, cuboidal. Urediniospores ellipsoid or obovate-oblong, 15-18 by 19-27μ; wall colourless, thin, finely and sparsely echinulate.

III. Telia amphigenous, chiefly epiphyllous. Teliospores in the epidermal cells, ellipsoid or globoid, 16-24 by 19-35μ; wall uniformly thin, pale yellowish, smooth.

Pycnia and aecia on the leaves and cones of *Tsuga canadensis* (L.) Carr., Pictou, July, 1911.

Uredinia and telia on *Rhodora canadense* (L.) BSP., Pictou.

This species was found to be rather common near Pictou on *Rhodora canadense.* The aecial stage was shown by cultures of the writer to occur on the leaves and cones of *Tsuga canadensis* (see Mycologia 4: 184. 1912). This stage was determined as *Peridermium Peckii* by Dr. Arthur. The aecia were much lighter in colour than the much more common aecia on *Tsuga canadensis* which has usually passed as *Peridermium Peckii.* The more common form doubtless belongs to *Pucciniastrum Myrtilli.*

Pucciniastrum Agrimoniae (Schw.) Tranz.

0 & I. Pycnia and aecia unknown.

II. Uredinia hypophyllous, thickly scattered over definite or extended yellowish areas, bullate, round, small, orange-yellow, dehiscent by a central pore; peridium rather delicate, hemispherical, cells small, cuboid. Urediniospores broadly obovate or globoid, 12-16 by 15-23μ; wall hyaline, rather thin, finely echinulate; contents orange-yellow, fading to pale yellow.

III. Telia hpyophyllous, forming scattered, irregular patches, indehiscent. Teliospores intercellular, beneath the epidermal cells, oblong or somewhat cylindrical, 18-30 by 19-32μ; wall smooth, brownish-yellow; contents colourless.

On *Agrimonia gryposepala* Wallr., New Glasgow, Truro.

This species was collected only near New Glasgow, but there was a rich development on the plants infected. The telia can be easily recognized when the leaves have been killed by the frost as small dark brown patches on the under side of the leaves. They are late of being formed and only in late collections will telia be found. Search was made on the neighbouring conifers in the spring for the aecial stage, but without success. Nothing whatever is known of it, but as *Pucciniastrum pustulatum* has aecia on *Abies* in Europe, this species may have like aecial hosts.

UREDINOPSIS Magn.

Cycle of development not understood; telia and two other spore forms known, called aecia and uredinia.

Aecia small, bullate, roundish, indehiscent. Peridium depressed globoid, delicate. Aeciospores borne singly on pedicels, obovate to globoid, angular or polyhedral; wall colourless, medium thick, minutely verrucose.

Uredinia bullate, roundish, usually larger than aecia, dehiscent by central rupture, spores ejected in a long white filament; peridium delicate. Urediniospores borne singly on

pedicels, fusiform, acute or beaked above, narrowed below; wall colourless, thin, smooth except two opposite longitudinal thickened ridges bearing single rows of minute projections, not always evident when wet.

Teliospores globoid, one to four-celled or more, usually with intersecting septa; wall smooth, colourless, thin.

This genus is found only on ferns. The species can usually be recognized in the field by the yellow areas, on the lower side of which the minute uredinia can be made out with a lens. Often the small white filiform columns of urediniospores can be seen, where they have emerged.

The teliospores can be studied best by sectioning the leaf, or if a small piece of the discoloured area be boiled for a few seconds in lactic acid the spores can then be made out with the aid of the microscope. Viewed from above they appear circular with the walls (if four-celled) appearing as two diameters at right angles. Viewed from the side they usually appear two-celled.

Dietel in "Engler and Prantl" regards the form, which Arthur places for convenience as an aeciospore, rather as a stalked teliospore, but its true position is not known.

Arthur in the "North American Flora" describes seven species, of these five are here described from Nova Scotia. The other two have been reported only from the Pacific coast.

From careful field study the writer believes that the fern rusts belonging to this genus are heteroecious, the aecidial stages in some species being found on *Abies balsamea*. This matter is discussed further under *Peridermium balsameum*.

Uredinopsis Osmundae Magn.

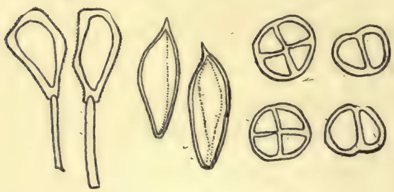
I. Aecia unknown.

II. Uredinia hypophyllous, on yellowish spots, usually bounded by veins, small, roundish, dehiscing by central opening, spores exuded in a white filiform column. Urediniospores oval or fusiform, sometimes clavate, 10-19 by 31-52μ, acute or

acuminate above, with a straight or bent beak, usually 8-15μ, sometimes obsolete, narrowed below and truncate; wall colourless, thin, smooth except for two longitudinal lines of delicate cilia.

III. Teliospores crowded in and beneath epidermal cells, globoid, ellipsoid or somewhat irregular, about 20-27μ broad by 18-32μ high, usually four-celled, sometimes two to many-celled; wall colourless, thin, smooth.

On *Osmunda cinnamomea* L., *O. Claytoniana* L., Pictou, Truro, Folleigh Lake, Oakfield; *O. regalis* L., Oakfield.



Uredinopsis Osmundæ. **Two aeciospores. Two uredinospores. Teliospores, surface view, cross section.**

This species is very common and widely distributed on *Osmunda cinnamomea* and *O. Claytoniana*. It is usually conspicuous from the sharply defined yellow areas between the veins. Collections in August and September show abundant development of both the uredinia and telia.

Uredinopsis mirabilis (Peck) Magn.

I. Aecia hypophyllous, scattered or somewhat gregarious, roundish, small; peridium strongly developed. Aeciospores angularly obovate or polyhedral, 15-20 by 24-36μ; wall colourless, medium thick, minutely verrucose.

II. Uredinia hypophyllous, scattered on discoloured areas, usually bounded by the veins, roundish, small, soon dehiscent by an apical rupture; peridium delicate. Urediniospores fusiform, ovate-fusiform or clavate, 12-17 by 27-55μ, acuminate above tapering into a beak 3-14μ long, wall colourless, thin, smooth except two lines of closely set minute spines.

III. Teliospores thickly scattered in the mesophyll of the leaf, globose or often broader than wide, usually about 22-32μ

broad by 19-25μ high, 2-4 celled; wall colourless, thin, smooth.

On *Onoclea sensibilis* L., Pictou, Truro, Folleigh Lake.

This species is abundant and usually shows a rich development of the uredinial stage on its host. The aecia are not common on my collections. Specimens of July 30 show abundant uredinia but no teliospores. August and September collections have well developed teliospores.

Uredinopsis Struthiopteridis Stoerm.

I. Aecia hypophyllous, scattered, roundish, bullate, pale yellow, peridium well developed. Aeciospores oblong or ovate, somewhat angular, 16-20 by 24-35μ; wall colourless, thick, especially at the angles, minutely verrucose; pedicels hyaline, usually shorter than spore.

II. Uredinia hypophyllous, scattered on yellowish or discoloured areas, roundish, pale yellow, dehiscent by an apical rupture; peridium delicate. Urediniospores mostly fusiform, 13-17 by 30-40μ, acute or accuminate, with a beak 3-8μ long; wall colourless, thin, smooth, with two longitudinal serrated ridges.

III. Teliospores in the mesophyll, abundant, globose, usually broader than high, 20-27μ broad by 14-22μ high, 2-4 celled wall colourless or slightly yellowish, thin, smooth.

On *Onoclea Struthiopteridis* (L.) Hoffmn., New Glasgow, Folleigh Lake.

Collections at Folleigh Lake on August 31, show all the stages well developed. The aeciospores in my collections are distinctly though finely verrucose even when wet.

Uredinopsis Atkinsonii Magn.

I. Aecia hypophyllous, on pale spots, small; peridium strongly developed. Aeciospores oval or obovate, angular, 12-20 by 25-43μ, sometimes acute; wall colourless, rather thick, closely and minutely rugose, appearing smooth when wet.

II. Uredinia hypophyllous, scattered on discoloured areas, roundish, very small, opening by a central aperture, the spores oozing out in a small column. Urediniospores ovoid or fusiform, 10-15 by 27-45μ, acute with apex prolonged into a slender beak, 5-16μ long; walls colourless, thin, smooth except two longitudinal lines of very minute papillae, only visible when dry.

III. Teliospores numerous, in the mesophyll of the leaf, aggregated in the areas occupied by the uredinia, globoid, 15-25 by 22-30μ, 2-4 celled, wall thin, colourless.

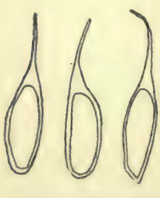
On *Aspidium Thelypteris* (L.) Sw., Pictou, Oakfield; *Asplenium Filix-femina* (L.) Bernh, Pictou.

This rust did not seem very common but was collected in several places near Pictou, the first collection being on September 11, 1909. My collections show abundant uredinia and telia but few aecia. It has been reported from Massachusetts but that seems to be the nearest station. It is probably, however, not rare.

Uredinopsis Phegopteridis Arth.

I. Aecia unknown.

II. Uredinia hypophyllous, scattered on discoloured areas bounded by the veins, roundish, small, brownish-yellow. Urediniospores ovoid or fusiform, 10-16 by 27-58μ; acute or accuminate, prolonged into a long and slender beak, 12-32μ long; wall colourless, thin, smooth except two longitudinal lines of minute papillae.



5. Urediniospores of *Uredinopsis Phegopteridis.*

III. Teliospores scattered in the mesophyll, 2-4 celled, chiefly globoid, 16-25μ in diameter; wall colourless, thin, smooth. On *Phegopteris Dryopteris* (L.) Fée, Pictou, September, 1910.

The long slender beak of this species is characteristic. It does not seem to be common. Arthur in the "North American Flora" records it only from Wisconsin.

CALYPTOSPORA Kühn.

Pycnia rarely seen. Aecia cylindrical, dehiscent at the apex. Peridium colourless. Aeciospores ellipsoid; wall colourless; contents orange. Telia forming continuous layers of considerable extent, indehiscent. Teliospores 4-celled by a vertical septa, formed in the epidermal cells.

Only one species is known. The telial stage of it is common in North America and Europe.

Calyptospora columnaris (Alb. & Schw.) Kühn.

Calyptospora Geoppertinana Kühn.

0. Not formed.

I. Aecia hypophyllous, in two rows, irregular rows on yellowish areas occupying the whole or part of the leaf, cylindrical, slender, about 1 mm. in length, dehiscent at apex; peridium colourless, finely lacerate, cells mostly elongate. Aeciospores broadly ellipsoid or ellipsoid, 12-18 by 18-25μ; wall colourless, thin, closely and distinctly verrucose; contents orange, fading to pale yellow or colourless.

II. Not formed.

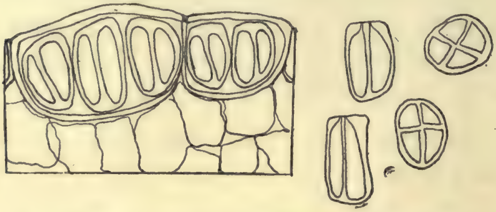
III. Telia caulicolous, forming a continuous layer around the stem, stems much thickened and often elongated, surface smooth shining reddish-brown, becoming dull. Teliospores in the epidermal cells, closely pressed together, usually 4-celled, oblong or somewhat ellipsoid, 12-20 by 22-40μ; wall pale yellowish-brown, smooth, thin, somewhat thickened at the apex.

Aecia on *Abies balsamea* (L.) Mill., Pictou, July 14, 1909.

Telia on *Vaccinium pennsylvanicum* Lam., Pictou, Truro.

The telial stage of this rust is very common about Pictou on *Vaccinium pennsylvanicum;* it was not found on *V. canadense*.

The aecial stage has never been collected elsewhere in North America. It is probably common but has been overlooked. The first collection was on July 14, 1909, and it was found to occur rather sparingly over a considerable area during that summer. In 1910 collections were made first on June 21 and the aecia soon became common, and in some shaded places were abundant and rather conspicuous on young trees. It was found rather common at the Park, Truro, and also at Oakfield, and doubtless is common throughout the province.



6. Section of telia of *Calyptospora columnaris*. Teliospores in longitudinal and cross section.

Using material from Pictou, Arthur (Mycologia 2: 231. 1910) sowed the teliospores of this rust on *Abies Fraseri* and the aecial stage developed. European investigators had previously established their connection. (For cultures by the writer see Mycol. 4: 177. 1912).

The aecial stage can be easily recognized as the spores are orange in colour and pycnia are absent, and no other *Peridermium* on *Abies balsamea* has these characters. No pycnia are formed, which is rare in the case of heteroecious rusts.

NECIUM Arth.

Cycle of development includes telia and possibly pycnia. Telia indehiscent, forming continuous layers, more or less distinguishable as compound sori. Teliospores oblong or prismatic, apparently one-celled; wall smooth, slightly coloured.

The description of the genus is based on Arthur's description in the "North American Flora."

Necium Farlowii Arth.

0, I & II. Wanting.

III. Telia amphigenous, mostly hypophyllous, also common on the young twigs and cones, forming compound raised sori on the leaves on the twigs and cones, usually a more or less continuous layer, reddish, waxy. Teliospores in the enlarged epidermal cells closely appressed, oblong or cylindrical, 7-16 by 35-90μ; wall pale brown, uniformly thin. Basidiospores spherical, 8-11μ in diameter, reddish yellow.

On *Tsuga canadensis* (L.) Carr., Pictou.

The life history of this species was worked out by the writer (see Mycologia 4: 182. 1912). The telia that were present on the twigs were found germinating on June 14, and well developed telia were collected on July 5.

The rust was locally abundant in the vicinity of Pictou during the seasons of 1910-11 and did considerable injury to the hemlocks. It was not found elsewhere in the province. It is inconspicuous when occurring on the leaves, but on the twigs it is quite conspicuous as they become swollen and much curved and soon bare of leaves. The affected cones in the early stages of infection are yellow in colour, later they become dark coloured.

Family 3. CRONARTIACEAE.

Similar to *Melampsoraceae* but the telia in columnar, filiform, wart-like, lens-shaped or cushion-like masses.

MELAMPSOROPSIS (Schroet.) Arth.

Aecia with well developed peridium. Aeciospores with colourless walls, closely verrucose with deciduous tubercules. Uredinia with delicate, evanescent peridium, sometimes wanting. Urediniospores formed in chains like aeciospores. Telia erumpent, naked, waxy becoming velvety. Teliospores in simple or branched cell-rows.

Five species are here reported from Nova Scotia. *M. Empetri* Schroet on *Empetrum nigrum* L. has been collected in New Hampshire and Quebec so that it may be expected to occur here.

Melampsoropsis Pyrolae (DC) Arth.

Chrysomyxa Pirolae (DC.) Rostr.

0. Pycnia episquamous, numerous, flat, forming continuous layers, not or slightly elevating the surface, producing yellowish areas on the scales.

I. Aecia chiefly episquamous, forming bullate swellings, irregularly round, large, crowded and often confluent, finally rupturing the epidermis, very pulverulent; peridium somewhat convex, soon falling away, cells coarsely tuberculate, resembling the spores. Aeciospores broadly elliptical or obovoid, variable in size, 19-30 by 24-45μ; wall colourless, thick, covered with large, crowded, deciduous tubercules.

II. Uredinia hypophyllous, small, circular, about 1 mm. in diameter, evenly and thickly distributed, usually occupying the whole under surface of the leaf; peridium delicate, walls smooth, colourless, thin. Urediniospores elliptical or obovate, often somewhat angular, 17-22 by 22-30μ; wall colourless, distinctly verrucose; contents reddish-orange.

III. Telia hypophyllous, evenly and closely scattered, Truro; *P. elliptica* Nutt., Pictou.

The uredinial and telial stages of this rust are very common near Pictou. In 1910 the uredinia were mature by May 7 and the telia germinating by May 20.

The life history of this species was established by the writer by cultures in the spring of 1911. (See Mycologia 4: 183. 1912). The aecial stage on the cones of *Picea* was common near Pictou in the season of 1910. It was rather rare the following year. The infected cones are quite conspicuous.

Melampsoropsis abietina (Alb. & Schw.) Arth.

Chrysomyxa Ledi De Bary.

0. Pycnia amphigenous, numerous, scattered, yellow, becoming reddish-brown, punctiform.

I. Aecia hypophyllous, on discoloured areas occupying part or all of a leaf, somewhat in rows, flattened laterally, low, dehiscent at apex; peridium colourless, lacerate, cells abutted. Aeciospores chiefly ellipsoid, 16-22 by 19-30μ; wall colourless, thick, densely and somewhat coarsely tuberculate, tubercules deciduous; contents orange-red.

II. Uredinia hypophyllous, on yellow spots, scattered or grouped, small, yellowish-red or brownish-yellow, roundish, about 130μ in diameter; peridium delicate. Urediniospores elliptical or subglobose, 13-20 by 18-33μ; wall colourless; closely and rather finely verrucose, tubercules deciduous; contents orange fading to colourless.

III. Telia hypophyllous, scattered or chiefly grouped on discoloured areas, small, .1-.3 mm., reddish at first. Teliospores oblong or cuboid, 11-19 by 16-30μ, in a series 70-90μ; wall colourless, thin, smooth; contents orange-red, fading to colourless.

Pycnia and aecia on *Picea rubra* (DuRoi) Dietr., Pictou.

Uredinia and telia on *Ledum groendlandicum* Oeder, Pictou.

The teliospores of this species were germinating freely in the summer of 1910 by the second week of June, the first collection being on June 10. Aecia were mature by the 17th of July.

The aecial stage of this rust, *Peridermium abietinum* (A. & S.) Arth., has not been recognized elsewhere in North America, though it was known in Europe on *Picea excelsa* (Lam.) Link. Cultures were made by the writer in 1910 and aecia were produced on *Picea rubra* from a sowing of the

germinating teliospores. (Mycologia 3:69. 1911). Field collections were also made near the rusted *Ledum* that seemed without doubt to be connected. These were sent to Dr. Arthur and were determined by him as *Peridermium abietinum.* All stages are very common in the neighbourhood of Pictou.

Melampsoropsis ledicola (Peck) Arth.

Chrysomyxa ledicola Lagerh.

0. Pycnia amphigenous, numerous, arranged in rows, prominent, punctiform, honey-yellow, becoming dark reddish-brown.

I. Aecia hypophyllous, in two rows on yellowish areas, occupying a part or all of the leaf, much compressed laterally, erumpent from elongated openings, low, dehiscent at apex, soon falling away; peridium colourless, margin lacerate. Aeciospores broadly ellipsoid or globoid, 20-35 by 20-50μ; wall colourless, thick, densely and rather coarsely verrucose; contents orange-red fading to colourless.

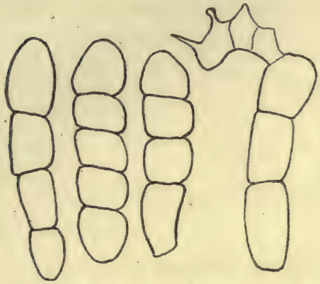
II. Uredinia epiphyllous, on reddish-brown spots, roundish or oblong-polygonal, early dehiscing, ruptured epidermis evident; peridium delicate. Urediniospores chiefly elliptical or globoid, 20-32 by 30-45μ; wall thick, colourless, verrucose with close set, deciduous tubercules; contents orange-red.

III. Telia epiphyllous, chiefly grouped on discoloured areas, irregular or roundish, small about .2-.5 mm. in diameter, ruptured epidermis evident. Teliospores oblong or cuboid, 16-22 by 18-33μ; wall colourless, thin, smooth, in a series 65-100μ long; contents orange-red when fresh.

Pycnia and aecia on *Picea canadensis* (Mill.) BSP., *P. rubra* (DuRoi) Dietr., *P. mariana* (Mill.) BSP., Pictou, Truro.

Uredinia and telia on *Ledum groenlandicum* Oeder, Pictou, Truro.

The connection of the aecial stage, *Peridermium decolorans* Peck, and the telial form on *Ledum,* was shown by cultures in 1910 by the writer. (See Mycologia 3: 70. 1911). The germinating teliospores of the rust on *Ledum* were sown on *Picea canadensis* and abundant pycnia and aecia developed.



7. Teliospores of *Melampsoropsis ledicola*, one germinating.

The aecial stage is very abundant about Pictou and doubtless throughout the province. The aecia begin to mature about the first of July. The telial stage is also common. The teliospores begin to germinate about the first of June, and when germinating are quite conspicuous. The uredinia were rare, only one collection being made.

The urediniospores and especially the teliospores are much larger than the measurements given in the "North American Flora" by Arthur.

Melampsoropsis Cassandrae (Peck & Clinton) Arth.

Chrysomyxa Cassandrae Tranz.

0. Pycnia amphigenous, numerous, scattered, conspicuous, punctiform, honey-yellow, becoming blackish-brown.

I. Aecia chiefly hypophyllous, in two irregular rows on yellowish spots occupying part or all of the leaf, flattened laterally, .5-1.5 mm. long, .5-.8 mm. high, dehiscent at the apex; peridium colourless, rather delicate, cells slightly overlapping. Aeciospores broadly ellipsoid or globoid, 17-24 by 24-33μ; wall colourless, medium thick, moderately and densely verrucose.

II. Uredinia hypophyllous in small groups; peridium inconspicuous, delicate. Urediniospores catenulate, elliptical,

16-19 by 21-30μ; wall colourless, thin, closely and prominently verrucose with deciduous tubercules; contents orange.

III. Telia hypophyllous, rather small, ruptured epidermis conspicuous, 130-500μ across, pale orange, inconspicuous. Teliospores oblong, 16-19 by 16-33μ, in a series 60-100μ long; wall uniformly thin, colourless, smooth, contents orange-red.

Pycnia and aecia on *Picea mariana* (Mill.) BSP., Pictou.

Uredinia and telia on *Chamaedaphne calyculata* (L.) Muench., Pictou.

The teliospores of this rust were germinating by June 13, and aecia were mature by July 17. The telial stage is fairly conspicuous when germinating, but rather inconspicuous before germination.

Cultures by the writer (Mycologia 3:68, 69. 1911) and field observations showed that *Peridermium consimile* Arth. and Kern, is the aecial stage. Clinton (Report Conn. Agr. Exper. Sta., pt. 6:386. 1907) described infection experiments that led to the same conclusion.

Melampsoropsis Chiogenis (Dietel) Arthur.

Chrysomyxa Chiogenis Deitel.

0 & I. Pycnia and aecia unknown.

II. Uredinia hypophyllous, scattered, roundish or irregular, flat, honey-yellow; peridium delicate, walls thin, smooth. Urediniospores catenulate, oblong to linear oblong, 14-21 by 22-40μ; wall colourless, coarsely verrucose with somewhat deciduous tubercules, medium thick; contents orange-yellow when fresh.

III. Telia hypophyllous, loosely scattered, round, small, orange-yellow fading to pale yellow, soon naked, ruptured epidermis noticeable; teliospores broadly oblong or squarish, 7-10 by 13-16μ in a series 30-80μ long; wall colourless, smooth, thin.

On *Chiogenis hispidula* (L.) T. & G., Pictou, Truro.

The description is based on that of Arthur in the "North American Flora." The collections contained only uredinia, but probably telia developed later. The species seems to be rather local in its distribution.

CRONARTIUM Fries.

Cycle of development includes pycnia, aecia and telia, heteroecious.

Pycnia broad and flat.

Aecia with membraneous peridium, rupturing at the sides. Aeciospores coarsely verrucose with deciduous tubercules.

Uredinia with peridium. Urediniospores borne singly on pedicels, pores obscure.

Telia erumpent, the catenulate teliospores adhering to form a long cylindrical or filiform column, horny when dry. Teliospores one-celled.

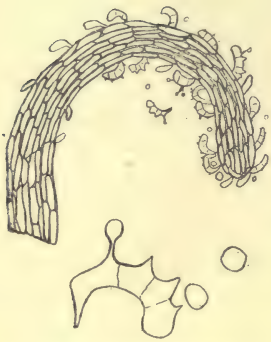
Cronartium Comptoniae Arth.

0 & I. On *Pinus rigida* Mill., *P. virginiana* Mill., *P. sylvestris* L. (Not collected in Nova Scotia).

II. Uredinia hypophyllous, scattered or gregarious, small, round, dehiscent by a central opening, pulverulent; peridium with polygonal cells, larger at the top with very thick walls. Urediniospores oval or obovate, 13-21 by 30-60μ; wall colourless, thick, sparsely and finely echinulate.

III. Telia columns hypophyllous, filiform, about 55-135μ thick and 1-1½ mm. long. Teliospores fusiform-oblong, 13-17 by 30-60μ; wall colourless, smooth, thin.

Uredinia and telia on *Myrica Gale* L., Pictou, August 25, 1910.


Telial column of *Cronartium* basidium with basidiospores

This species was found only at Cole's Pond, near Pictou. A few of the teliospores were germinating when collected. It was rather abundantly developed in a limited area.

Clinton (Report Conn. Agric. Exper. Sta. Pt. 6:380. 1907) sowed the spores of *Peridermium pyriforme* Peck on *Myrica asplenifolia* and the uredinia of this rust appeared. He thinks it probable that this species is identical with the European *Cronartium asclepiadeum* Fr.

Family 4. PUCCINIACEAE.

Basidia external, i. e. germinating by a typical promycelium. Telia usually erumpent, firm or pulverulent. Teliospores fasicled or free, pedicelled; wall firm or with outer gelatinous layer, overlaid by the cuticle.

The great majority of rusts belong to this family. The teliospores may be one-celled as in *Uromyces* or two-celled as in *Puccinia* or several celled as in *Phragmidium*.

UROMYCES Link.

Nigredo Roussel.

Pycnia immersed in the tissue of the host, globose or subglobose with projecting neck. Aecia with evident peridium, finally cup-shaped. Aeciospores without distinct germ-pores. Urediniospores formed singly on distinct pedicels with several germ-pores, echinulate or verrucose. Teliospores unicellular, formed singly on distinct pedicels with a single apical germpore. Basidiospores inequilateral, nearly reniform.

The one-celled teliospore with a single apical germ-pore separates this genus from *Puccinia*. They are alike in other respects. Though the teliospores and urediniospores are both one-celled in *Uromyces* they may be easily distinguished, as the urediniospores are always echinulate or verrucose with several germ-pores, while the teliospores are usually smooth (sometimes verrucose) with only one apical germ-pore. The wall of the teliospore is, also, usually thicker.

Arthur divides this genus chiefly into four as follows:

Life cycle with all the spore forms......Nigredo.
Life cycle with pycnia, aecia and telia....Uromycopsis.
Life cycle with pycnia, uredinia and telia.Klebahnia.
Life cycle with pycnia and telia.........Telospora.

The genus is a very large one embracing over 500 species.

Uromyces Scirpi Burr.

Nigredo Scirpi (Cast.) Arth.

0. Pycnia amphigenous, numerous, scattered, inconspicuous.

I. Aecia amphigenous, gregarious, on discoloured spots, short cylindrical; peridium pale yellowish, the margin lacerate, recurved. Aeciospores globoid or broadly ellipsoid, 16-21 by 18-24μ; wall colourless, thin, minutely verrucose.

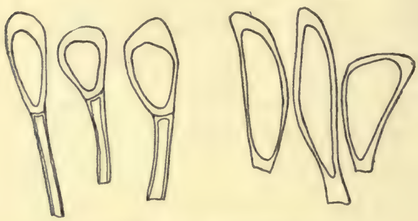
II. Uredinia amphigenous, elongate, remaining covered for some time by the epidermis. Urediniospores mostly ellipsoid, 16-23 by 22-40μ; wall light brown, sparingly echinulate, pores 3 or 4, equatorial.

III. Telia amphigenous, oblong or linear, long covered by epidermis, compact, brownish-black. Teliospores fusoid or clavate ellipsoid, 17-22 by 33-46μ, rounded at the apex, sometimes conical; wall light brown, thickened at the apex to 8μ; pedicel firm, hyaline, or light brown, equalling or longer than the spore.

Pycnia and aecia on *Cicuta maculata* L. Not collected in Nova Scotia, but obtained from cultures by the writer. (See Mycologia 4:178. 1912).

Uredinia and telia on *Scirpus campestris* Var. *paludosus* (A. Nelson) Fernald, *S. validus* Vahl., Pictou.

Arthur has shown by cultures that aecial stage is on *Cicuta maculata* (Arthur, Jour. Mycol. 13:199. 1907). European investigators have shown that this species produces aecia on a number of different hosts. Arthur in the "North American Flora" lists collections of aecia on *Cicuta bulbifera* L., *Oenanthe californica* S. Wats., *Sium cicutaefolium* Schrank, and *Glaux maritima* L. as belonging to this species as well as the aecia on *Cicuta maculata*.



Teliospores of *Uromyces Scirpi*.

The description is from the collection on *Scirpus campestris* Var. *paludosus*. The uredinia and urediniospores are similar on *Scirpus validus* except that the uredinia remain covered in the latter. The telia on *Scirpus validus* are placed immediately beneath the stomata embedded in the tissues; they are small, numerous, and do not break through the epidermis. The teliospores are sometimes as long as 70μ and somewhat irregular in shape, probably due to the pressure of the strong epidermis. The pedicel is very short or obsolete.

Uromyces perigynius Halsted.

Uromyces Solidagini-Caricis Arth.

Nigredo perigynia (Halsted) Arth.

0. Pycnia epiphyllous, sometimes amphigenous, grouped on yellow spots, honey-yellow.

I. Aecia hypophyllous, often circinate; peridium pale, low, cylindrical, margin revolute, lacerate. Aeciospores globoid, about 15-16μ; wall colourless.

II. Uredinia hypophyllous, small, oval, up to $\frac{1}{2}$ mm. in length, ruptured epidermis evident, ferruginous, pulverulent. Urediniospores oval or obovate, 13-18 by 19-25μ; wall medium thick, pale brown, finely echinulate, two equatorial germ pores.

III. Telia hypophyllous, oblong or linear, pulvinate, firm, soon naked, dark chestnut-brown or black. Teliospores obovate, rounded or obtuse above, narrowed below, 14-22 by 24-35μ; wall smooth, thin, light brown, much thickened at the apex, 6-12μ; pedicel slender, tinted, as long as the spore or longer.

Aecia on *Solidago bicolor* L. and other species of *Solidago*, Pictou and vicinity.

Telia and uredinia on *Carex deflexa* Hornem., *C. flava* L., *C. intumescens* Rudge, *C. novae-angliae* Schwein., *C. tribuloides* Wahlenb. and Var. *reducta* Bailey, *C. scoparia* Schkuhr., Pictou and surrounding districts.

This species also has aecia on *Aster*. (See Arthur, Mycologia 4:21. 1912).

The writer by cultures (Mycologia 4:181. 1912) showed that this rust has aecia on *Solidago* species. Arthur had previously established this connection.

It seems probable that there is only one species of *Uromyces* rust on the sedges in this vicinity, that is, all belong to this species. It is very common on *Carex scoparia*.

Uromyces Poae Rab.

Nigredo Poae (Rab.) Arth.

0. Pycnia amphigenous, mostly crowded on spots bearing aecia, honey-yellow.

I. Aecia mostly hypophyllous, also epiphyllous and petiolicolous, crowded in small groups on discoloured often depressed areas, low, small; peridium lacerate. Aeciospores yellow, becoming colourless, subglobose or polygonal, 16-24μ; wall colourless, finely verrucose.

II. Uredinia hypophyllous, linear, long covered by the epidermis, 1 mm. or less in length. Urediniospores globose or elliptical, 16-29 by 19-24μ; wall pale brown, rather thin, finely echinulate.

III. Telia hypophyllous, small, black or dark brown, mostly oval or linear, long covered by the epidermis. Teliospores variable in form, obovate, broadly clavate or oval, 16-23 by 23-33μ; wall brown, smooth, scarcely thickened at the apex; pedicel brown, much shorter than the spore, persistent.

Pycnia and aecia on *Ranunculus repens* L., Pictou, May 25, 1910.

Uredinia and telia on *Poa trivialis* L., Pictou, July 17, 1910.

This is an European species of which neither aecial nor telial stage has been previously reported from North America. It was collected in only one place. The aecia were collected in the spring, and in July the other stages were found to be common on *Poa* that grew near.

Uromyces Peckianus Farl.

Nigredo Peckiana (Farl.) Arth.

0. Pycnia amphigenous, usually in small groups surrounded by the aecia.

I. Aecia amphigenous, on rounded spots, circinating, bright orange, long cylindrical, lacerate. Aeciospores angular globose or ellipsoid, about 16-22μ; wall nearly colourless, medium thick, contents orange, fading to pale yellow.

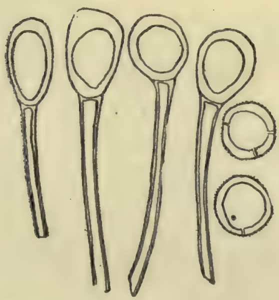
II. Uredinia epiphyllous, scattered or in lines, oblong or linear, ochraceous-brown, pulverulent, surrounded by the ruptured epidermis. Urediniospores mostly globose, 19-24μ; wall yellowish-brown, thick, about $2\frac{1}{2}\mu$, finely and densely verrucose.

III. Telia mostly epiphyllous, sometimes hypophyllous, scattered, often confluent, abundant, rounded oblong or linear, often 1 cm. or more in length, pulvinate, dark brown or black. Teliospores globose, subglobose, obovate or elliptical, 13-22 by 19-40μ; wall dark brown, smooth, thickened at the apex; pedicel hyaline, much longer than spore; a few two-celled spores present.

Pycnia and aecia on *Atriplex patula* L., *A. patula* Var. *hastata* (L.) Gray, Pictou, May 21, 1910. (*Chenopodium album* L., shown by cultures, not collected).

Uredinia and telia on *Distichlis spicata* (L.) Greene.

The life history of this rust was made out by the writer by cultures during the spring of 1910 (Mycologia 3: 72-74. 1911). Sowings of the teliospores were were successful on *Chenopodium album* and *Atriplex patula* Var. *hastata*. Collections of aecia were made on *Salicornia europea* L. and *Suedia maritima* which probably also belong to this rust. They were collected beside the rusted *Distichlis* and were morphologically similar to the aecia on *Atriplex*.



Uromyces Peckianus. Four teliospores, two urediniospores.

Infection experiments by Arthur (Jour. Mycol. 1:234. 1909) showed that *Puccinia subnitens* Dict. on *Distichlis spicata* has aecia on *Chenopodium*, *Atriplex* and other plants. The aecia of both rusts are similar and cannot be separated easily. These facts suggest the possibility that the rusts were once identical

and that the *Puccinia* has in course of time developed from the *Uromyces.* The urediniospores are also alike and a few mesospores are present in the *Uromyces,* which would tend to strengthen the supposition.

Uromyces Spartinae Farl.

Uromyces acuminatus Arth.

Nigredo Polemonii (Peck.) Arth.

0. Pycnia chiefly epiphyllous, gregarious, in small groups, not conspicuous, punctiform, honey-yellow, becoming brownish.

I. Aecia chiefly hypophyllous, gregarious, more or less crowded in groups on slightly discoloured spots, cupulate or cylindrical, margin lacerate, slightly recurved. Aeciospores. subgloboid, 15-24 by 18-27μ; wall colourless, rather thin, evenly and finely verrucose.

II. Uredinia epiphyllous, intercostal, linear, soon naked, ruptured epidermis evident, yellowish-brown, not inconspicuous. Urediniospores globose or broadly elliptical, large, 22-32μ in diameter, a few 25 by 35μ; wall thick when immature, becoming thinner, yellowish, rather sparsely echinulate, pores large, scattered.

III. Telia similar to the uredinia but blackish-brown and more conspicuous; teliospores obovate or oblong-clavate, 15-22 by 22-42μ; wall dark brown, apex darker and thickened, 6-10μ, usually rounded or acuminate above, base narrowed; pedicel slightly coloured, firm, usually longer than the spore, often twice its length.

Pycnia and aecia on *Arenaria laterflora* L., *Spergularia canadensis* (Pers.) Don., Pictou.

Uredinia and telia on *Spartina patens* (Ait.) Muhl., *S. glabra* Var. *alternifolia* (Loisel) Merr., *S. Michauxiana* Hitchc., Pictou.

This species is composed of distinct races. In this vicinity the form on *S. patens* infects *Spergularia,* that on *S. Michauxiana* and *S. glabra alterniflora* infects *Arenaria.* This has been shown by cultures of the writer. (Mycologia 4:186. 1912). In the interior of North America the form on *S. Michauxiana* infects *Polemonium* and another form on the same host infects *Steironema.* This has been shown by cultural experiments by Arthur (Jour. Mycol. 12:24. 1906).

Uromyces Silphii (Syd.) Arth.

Uromyces Junci-tenuis Syd.

Nigredo Silphii (Desmaz.) Arth.

0. Pycnia chiefly epiphyllous, in small groups, golden-brown.

I. Aecia amphigenous, in groups 4-10 mm. across, crowded about the pycnia on discoloured spots; peridium colourless, margin recurved, lacerate. Aeciospores angularly globoid, small, 13-18μ; wall colourless, thin, minutely verrucose.

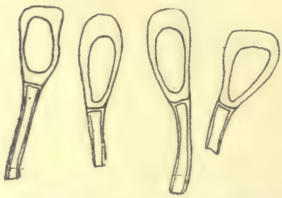
II. Uredinia amphigenous, scattered, roundish or somewhat elongated, small, tardily naked, dark cinnamon-brown, ruptured epidermis not conspicuous. Urediniospores broadly ellipsoid or sometimes obovate, 13-19 by 15-23μ; wall golden yellow, sparsely and bluntly echinulate, pores 5 or 6, scattered.

III. Telia amphigenous, scattered, roundish or somewhat elongated, small, tardily naked, firm, somewhat pulvinate, blackish-brown, ruptured epidermis noticeable. Teliospores angularly obovate, rounded, truncate or occasionally pointed above, usually narrowed below, 12-19 by 26-35μ; wall chestnut-brown, much thickened above, 7-10μ, smooth; pedicel light-chestnut brown, one to one and a half times the length of the spore.

Aecia on *Silphium integrefolium* Mich., *S. teribinthinaceum* Jacq., *S. perfoliatum* L., *S. laciniatum* L. (Not collected in N. S.)

Uredinia and telia on *Juncus tenuis* Wild., Pictou and vicinity.

The collections of this rust were so badly parasitized that the description is largely based on Arthur's original description (Jour. Mycol. 13: 202. 1907). The aecial hosts are not found in Nova Scotia. The rust is common.



Teliospores of *Uromyces Silphii.*

The rust has generally passed as *Uromyces Junci* (Desm.) Tul. Arthur (l. c.) showed by cultures that the aecial stage is on *Silphium* and separated the rust. The European *Uromyces Junci* has its aecia on *Pulicaria dysinterica.* A rust not morphologically distinct is found in western North America and has passed under the name of *Uromyces Junci* though no cultures have been made to determine its aecial stage.

Uromyces effusus Arth.

Uromyces Junci-effusi Syd.

Nigredo Junci-effusi (Syd.) Arth.

0 & I. Pycnia and aecia unknown.

II. Uredinia amphigenous, scattered, oblong or linear, tardily naked, dark cinnamon-brown, ruptured epidermis evident. Urediniospores broadly ellipsoid or oval, 14-19 by 18-26μ; wall light yellow, sparingly and bluntly echinulate, pores 4, equatorial.

III. Telia amphigenous, numerous, scattered or collected in groups about stem, oblong or linear, sometimes confluent, ruptured epidermis conspicuous. Teliospores obovate or oval,

12-17 by 20-30μ, rounded, obtuse or acute at apex, mostly narrowed below; wall light chestnut-brown, thickened at apex, 5-10μ, smooth; pedicel yellowish, persistent, about the length of the spore.

On *Juncus filiformis* L., Pictou.

Nothing is known of the aecial stage of this rust. It was found in only one place, and, though careful watch was kept for two seasons in the neighbourhood, no aecia appeared except those that have already been connected.

This collection adds a new host, as all previous collections were on *Juncus effusus* L.

This species is found throughout the eastern United States on *Juncus effusus* L. It has passed under the name *U. Junci* (Desm.) Tul., but Arthur (Jour. Myc. 13: 192. 1907) shows that it is morphologically distinct, especially as the urediniospores are echinulate and four-pored instead of verrucose and two-pored, as in *U. Junci.* He gives the following key to separate the three common species of *Uromyces* on *Juncus:*

Urediniospores verrucose, pores 2, equatorial—*U. Junci* (Desm.) Tul.

Urediniospores echinulate, pores 4, equatorial—*U. effusus* Arth.

Urediniospores echinulate, pores 5-6, scattered—*U. Silphii* (Syd.) Arth.

Uromyces Polygoni (Pers.) Fuck.

Nigredo Polygoni (Pers.) Arth.

0. Pycnia yellow to honey-colour, in small groups.

I. Aecia mostly hypophyllous, crowded in roundish groups, peridium rather low, with broad, whitish, torn edges. Aeciospores subglobose, 16-18μ, pale yellow to orange, verrucose.

II. Uredinia amphigenous, mostly hypophyllous, rounded or oval, pulverulent, surrounded by the ruptured epidermis. Urediniospores ellipsoid or obovate, 16-20 by 21-27μ; wall yellowish, very finely and densely echinulate, pores 2, lateral.

III. Telia scattered, roundish on leaves, abundant and elongated on the stem, pulvinate, blackish. Teliospores globose or subglobose, 19-24 by 24-38μ, rounded or pointed above, wall chestnut-brown, apex thickened up to 7μ; smooth; pedicels tinted, persistent, firm, long, usually much longer than the spore.

On *Polygonum aviculare* L., Pictou, Truro.

This is a cosmopolitan species, and is probably common. The collections were made in the fall, so no aecia were present. The teliospores are not formed till late summer.

Uromyces Arisaemae Cke.

Uromyces Caladii Farl.

Nigredo Caladii (Schw.) Arth.

0. Pycnia hypophyllous, scattered.

I. Aecia hypophllous or petiolicolous, scattered, abundant, low, margin erose. Aeciospores subglobose or ellipsoid, often angular, 18-24 by 22-25μ, verrucose.

II. Uredinia amphigenous, scattered, rounded or oblong, often covered by the epidermis, frequently confluent. Urediniospores pear-shaped, base truncate, 15-21 by 25-32μ, conspicuously echinulate.

III. Telia amphigenous, mostly epiphyllous, abundant, scattered, rounded or oblong, long covered by the conspicuous epidermis, sometimes confluent, somewhat pulverulent, brown. Teliospores oval, subglobose or ovate, 19-27 by 27-40μ; wall light yellowish-brown, uniform in thickness, with a small, hyaline, apical papilla, (cometimes more than one), pedicel hyaline, fragile, deciduous, about the length of the spore.

On *Arisaema triphyllum* (L.) Schott., Pictou, Truro.

This species is doubtless common. Collections made throughout the summer show no uredinia and only a few urediniospores mixed with the teliospores.

Uromyces Limonii (DC.) Lév.

Nigredo Limonii (DC.) Arth.

0. Pycnia amphigenous mostly hypophyllous, accompanying the aecia, numerous, brown.

I. Aecia amphigenous, in circular groups on brown or reddish spots, peridium short, cylindrical, margin whitish, lacerate. Aeciospores angular-globose or ellipsoid, 18-26 by 21-32μ, yellowish, finely verrucose.

II. Uredinia amphigenous, scattered, mostly rounded on the leaves, oblong on the stem, long covered by the epidermis, at length naked, pulverulent, cinnamon-coloured. Urediniospores globose, subglobose or ovate, 20-28 by 22-32μ, yellowish-brown, densely verrucose, 2-3 pores.

III. Telia amphigenous, scattered or in circular groups, mostly rounded on the leaves, oblong on the stem, long covered by the epidermis, at length naked, surrounded by the ruptured epidermis, pulvinate, brownish-black or black. Teliospores subglobose, mostly clavate or oblong, sometimes angled and irregular, 19-27 by 27-44μ, apex rounded or conical, base narrowed; wall brown, thickened at apex up to 8μ, smooth; pedicel persistent, tinted, usually longer than spore.

On *Limonium carolinianum* (Walt.) Britton, Pictou, September, 1909.

The collections on this plant showed an abundant development of aecia and telia, but no uredinia. The first collection of mature aecia was on June 10, 1910.

Uromyces Fabae (Pers.) De Bary.

Nigredo Fabae (Pers.) Arth.

0. Pycnia hypophyllous, scattered among the aecia.

I. Aecia hypophyllous, on yellow spots, solitary or in rounded or elongated groups; peridium short, cup-shaped, margin incised, revolute, whitish. Aeciospores angular globose or ellipsoid, 12-14μ in diameter, yellowish, finely and densely verrucose.

II. Uredinia amphigenous, mostly scattered, circular on the leaves, elongated on the stem, small, pulverulent, light brown, surrounded by the ruptured epidermis. Urediniospores mostly ellipsoid or ovate, 18-21 by 23-30μ; wall yellowish, becoming light brown, sparingly echinulate, usually 3 sometimes 4 pores.

III. Telia amphigenous, rounded on the leaves, elongate and more abundant on the stem, pulvinate, dark brown to blackish-brown. Teliospores obovate, clavate or subglobose, 17-24 by 22-43μ, rounded or conical, sometimes truncate above; wall brown, thickened at apex up to 10μ, smooth; pedicel persistent, thickened, coloured, equalling or longer than spore.

On *Vicia cracca* L., Pictou.

This species is found on several genera of the *Leguminosae.* It was collected on only one species, and seemed to be common on that host. On some host plants aecia are abundantly produced, on others they do not seem to occur. It may be that *Vicia cracca* belongs to the latter class as no aecia were found.

Uromyces Trifolii (Hedw. F.) Lév.

Nigrego fallens (Desmaz.) Arth.

0 & I. Pycnia and aecia unknown.

II. Uredinia hypophyllous or petiolicolous, mostly scattered, small, sometimes confluent, pulverulent, soon naked, surrounded by the ruptured epidermis, light brown. Urediniospores globose, subglobose or ellipsoid, 22-27 by 23-30μ; wall about 2μ thick, yellowish-brown, sparingly echinulate, pores 5-7.

III. Telia mostly caulicolous, oblong or rounded, sometimes confluent, covered for some time by the epidermis, at length naked, pulverulent, dark brown. Teliospores globose, subglobose, elliptical or oblong, 19-24 by 22-32μ, rounded at the apex, with a small apical papilla at the germ-pore; wall bright brown, smooth (sometimes very finely verrucose); pedicel hyaline, slender, deciduous, about the length of the spore.

On *Trifolium pratense* L., Pictou.

The uredinal stage of this rust is very common on clover, and must cause a considerable amount of injury. No aecial stage is known.

Uromyces Trifolii-repentis Liro.

Nigredo Trifolii (Hedw. F.) Arth.

0. Pycnia chiefly epiphyllous, in small groups or spread over larger areas, not conspicious.

I. Aecia amphigenous, in roundish groups, or on the veins and petioles in elongate groups, short cupulate; peridium white erect, or slightly recurved, finely erose. Aeciospores broadly ellipsoid or somewhat angular, 15-17 by 16-21μ; wall light yellow or nearly colourless, thin, finely verrucose.

II. Uredinia similar to *U. Trifolii,* but there are 3 or 4 equatorial germ pores, instead of 4-6 scattered ones.

III. Telia similar to those of *U. Trifolii.*

On *T. hybridum* L., Pictou.

This species differs from the more common rust on red clover by the presence of aecia on the same host as the uredinia and telia, also by the different number of germ pores in the urediniospores. It is also found on *Trifolium repens L.*

The aecial stage was not collected. The description given is based on that in the "North American Flora."

Uromyces Hyperici-frondosi (Schw.) Arth.

Nigredo Hyperici-frondosi (Schw.) Arth.

Uromyces Hyperici Curt.

0. Pycnia mostly hypophyllous; accompanying the aecia, subepidermal, somewhat globose, about 140μ in diameter, becoming blackish.

I. Aecia hypophyllous and caulicolous, on orbicular yellow or purple spots 2-4 mm. in diameter, in small rounded groups on leaves, larger groups on the stem and leaf veins, cup-shaped, margin revolute, incised. Aeciospores angularly globose, 16-22μ in diameter, finely verrucose.

II. Uredinia hypophyllous, scattered, sparingly developed, small, rounded, yellowish-brown. Urediniospores globose, subglobose or ellipsoid, 15-20 by 18-27μ; wall light brown, finely echinulate.

III. Telia hypophyllous or caulicolous, sometimes on purplish spots, small and rounded on leaves, larger and elongated and in groups on the stem, sometimes confluent, pulvinate, blackish-brown or black. Teliospores subglobose ovate or oblong, mostly ovate, 16-19 by 19-33μ, apex mostly rounded; wall pale brown or dark brown, thickened at the apex up to 9μ,

smooth; pedicel hyaline or coloured above, equalling or exceeding spore, fragile.

On *Hypericum virginicum* L., Pictou; *H. canadense* L., Pictou; *H. ellipticum* Hook., Pictou, Folleigh Lake.

This species is very common on the genus *Hypericum* in the vicinity of Pictou. The teliospores on *H. ellipticum* show a much less thickened apex than on the other host plants.

PHRAGMIDIUM Link.

Aecia of the caeoma type without peridium, but surrounded by a dense crown of paraphyses. Aeciospores with numerous germ-pores, scattered; wall colourless. Uredinia also surrounded by paraphyses. Urediniospores singly not in chains, with numerous germ-pores. Teliospores three or more celled in a vertical row (rarely two celled), usually several germ-pores in each cell.

This genus occurs only on the rose family. Dietel (Hedwigia 44:344. 1905) records 46 species, of these 17 are found in North America and four are here reported from Nova Scotia. Arthur has added a new species from the western United States. (Torreya 9:24. 1909).

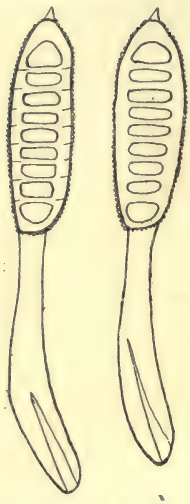
Phragmidium americanum Diet.

0, I & II. Pycnia, aecia and telia not collected. All are formed.

III. Telia hypophyllous, on reddish-brown, small, irregular spots, mostly scattered, small, black, readily detachable. Teliospores oblong, 46-86 by 24-26μ, obtuse at the apex with colourless apiculus, mostly 7-10 celled; wall dark brown or almost black, verrucose; pedicel longer than the spore, hyaline, swelling in water at base.

On *Rosa* species, Pictou, New Glasgow.

This species was for some time confused with *Phr. subcorticium* (Schrnk) Wint. (*Phr. mucronatum* Lk.). Peck first called attention to a variation in the number of cells. He states that "American specimens generally have the spores more opaque and with two or more septa than the typical form. This variant form might be called Var. *americanum*." (N. Y. State Mus. Rep. 28: 86). Dietel raised the variety to specific rank under the name of *Phr. americanum*.



Teliospores of *Phragmidium americanum.*

According to Arthur *Phr. americanum* inhabits the north-eastern region of North America along the Atlantic coast from Maryland northward and north of the great lakes, chiefly on *Rosa blanda, R. lucida, R. Sayi* and certain cultivated varieties derived from these (Torreya 9:27. 1909).

It seems to be common on the roses in this vicinity. Collections of another stage of the rust were made but they were lost in drying. The collection reported in Dr. MacKay's Fungi of N. S. (Trans. N. S. Inst. of Science 12: 124) as *Phr. subcorticium* belongs here.

Phragmidium imitans Arth.

Phragmidium gracile Arth.

0. Pycnia not observed.

I. Aecia rounded, small, scattered, epiphyllous, soon naked, yellowish. Aeciospores rounded, oblong, elliptical or oval, 16-24 by 12-29μ; wall unequally thickened, echinulate; paraphyses slender, long, clavate, hyaline, incurved.

II. Uredinia hypophyllous, scattered, small, rounded. Urediniospores elliptical or obovate, 12-16 by 20-24μ; wall rather thick, colourless, echinulate; paraphyses slender, clavate, thin-walled, hyaline, about 13-22 by 55-80μ, incurved.

III. Telia hypophyllous, scattered, or somewhat grouped, small. Teliospores cylindrical, dark brown, 5-10 celled, rounded above with a hyaline apiculus 5-10μ, 26-31 by 75-127μ, verrucose; pedicel hyaline, tinted above, equal to or longer than the spore.

On *Rubus idaeus* Var. *aculaetissimus* (C. A. Mey) Regel & Tiling, Oakfield, August 13, 1910.

The description of the aecia is based on that given by Saccardo.

Phragmidium imitans is a common species throughout northern North America. However, it does not seem to be common in Nova Scotia as only one collection was made.

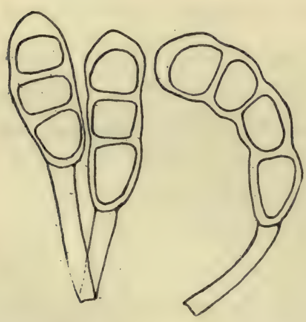
Phragmidium Potentillae-canadensis Diet.

Kuehneola obtusa (Strauss) Arth.

0. Pycnia epiphyllous in small crowded groups.

II. Uredinia hypophyllous, on reddish spots, orange-red, roundish, scattered or gregarious, pulverulent, surrounded by clavate paraphyses. Urediniospores globose, elliptical or ovate, 13-18 by 16-22μ, echinulate.

III. Telia hypophyllous, small, orbicular, scattered, brown, pulverulent, soon naked. Teliospores oblong, 21-24 by 46-85μ, sometimes curved, mostly 3-4 septate, somewhat constricted at the septum, usually obtuse at the apex, (wall of lower cell often hyaline), smooth; pedicel even, colourless, usually about the length of the spore.



Teliospores of *Phragmidium Potentillae—canadensis.*

On *Potentilla canadensis* L., Pictou, New Glasgow.

A very common rust. The uredinia and telia are usually parasitized by *Darluca filum.*

Arthur in the "North American Flora" places this species in the genus *Kuehneola* on account of the absence of the aecia.

Phragmidium speciosum Fr.

Earlia speciosa (Fr.) Arth.

0. Pycnia mostly hypophyllous, in groups opposite aecia.

I. Aecia hypophyllous, petiolicolous or caulicolous, sometimes epiphyllous, often developing on the fruit, solitary or in irregular groups, small or occupying considerable areas, up to 1 cm. long on the stem, orange; paraphyses mostly oblong or clavate, usually 8-15 by 40-50μ. Aeciospores globose, subglobose or ellipsoid, 20-25 by 22-35μ; wall pale yellowish, verrucose, contents orange.

II. Uredinia wanting.

III. Telia caulicolous or especially fruiticolous, producing swellings on stem and pedicels, large, sometimes 2 x 1 cm. compact, black. Teliospores cylindrical, sometimes somewhat ellipsoid, 29-33 by 60-115μ, usually rounded below, slightly narrowed above, cells 3-9, apex with sub-hyaline papilla; wall brown to black, about 4μ thick; pedicel hyaline or tinted above, very long, 8-10 times the length of the spore or longer, not swelling in water.

On *Rosa* (species not determined), Pictou.

This rust is very common on the wild roses about Pictou. It attacks especially the pedicels and the fruit, the affected fruit remaining green and not changing to the normal red colour.

It occurs upon any and all species of roses and is widely distributed in the United States and Canada. Arthur places this species in the genus *Earlia,* as it differs from the true members of the genus *Phragmidium* in the gelatinous pedicels of the teliospores, the large compact telia on the stems and the absence of uredinia.

KUEHNEOLA Magnus.

Like *Phragmidium* but teleutospores colourless, germ-pore under cross wall, and spores germinating when mature.

Kuehneola albida Magn.

Kuehneola Uredinis (Link) Arthur.

0. Pycnia epiphyllous, in small crowded groups on reddened spots.

I. Aecia wanting.

II. Uredinia mostly hypophyllous, pulverulent, orange-yellow; paraphyses wanting. Urediniospores usually ellipsoid, about 15-20 by 20-27μ; wall colourless, moderately thin, closely verrucose-echinulate.

III. Telia hypophyllous, scattered, irregularly roundish, early naked, pulvinate, velvety, yellowish or pure white, ruptured epidermis inconspicuous. Teliospores cylindrical or cylindrical clavate, 18-24 by 85-110μ, irregularly flattened or coronate above, narrowed below, 5-13 celled, usually 5-6 celled, each cell about 20 by 25μ, trapezodial and articulated to the cell above by a projection containing the pore; wall colourless, thin, the apical thicker above, the other cells thickened above uniformly or only at the lateral projections, smooth or slightly roughened at apex; pedicel colourless, terete, very short, often seemingly wanting.

On *Rubus hispidus* L., Pictou.

The description is based on that of Arthur in the "North American Flora." The rust does not seem to be common as it was collected only in one place but occurred there quite abundantly on its host.

TRIPHRAGMIUM Link.

Teliospores of three cells united in the form of a triangle, a basal cell supporting two others alongside of each other.

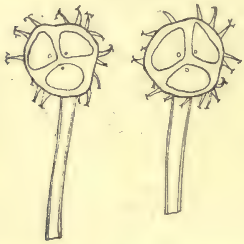
Triphragmium clavellosum Berk.

Nyssopsora clavellosa (Berk) Arthur.

0. Pycnia unknown, possibly not formed.

I & II. Aecia and telia wanting.

III. Telia epiphyllous, rarely on stems, on circular yellowish spots about 4 mm. in diameter which may become purplish, crowded, often circinate, sometimes confluent, small, mostly circular, about .3-.4 mm. in diameter, sometimes elongate, surrounded by the ruptured epidermis, pulverulent, black. Teliospores three-celled, somewhat triangular or truncate-obovate, about 27-33μ; wall dark brown, with bent spines up to 11μ, tips forking and recurved; pedicel hyaline, exceeding the spore. On *Aralia nudicaulis* L., Pictou, New Glasgow.



Teliospores of *Triphragmium clavellosum*.

The large black groups of telia, which are sometimes very abundant on the upper surface of the leaves make this a very conspicuous rust.

GYMNOSPORANGIUM Hedw, F.

Aecia with well developed peridium dehiscing by longitudinal slits. Teliospores two-celled (rarely 3-5-celled), embedded in a gelatinous matrix, germ-pores usually more than one in a cell and lateral. Uredinia unknown.

The telial stage of the species of this genus as far as is known infest the *Cupresseae,* the majority of the species occurring on *Juniperus.* The aecial stage occurs on the tribe *Pomeae* of the family *Rosaceae.* The only exception to this is *Gymnosporangium externum* Arth. & Kern, in which the aecial stage is found on *Gillenia stipulaceae* (Mycologia 1:253. 1909).

The name *Roestelia* has been applied to the aecial stage of the *Gymnosporangium* rusts. Usually the peridium dehisces by longitudinal slits, and thus soon becomes fimbriate and revolute. Some species have their aecial stage on the apple and often cause serious damage. No uredinial stage is known. This is remarkable as all other heteroecious rusts possess all the spore forms.

The genus is characterized by the teliospores having long hyaline pedicels which swell in moisture and form a jelly-like matrix in which the spores are embedded. This yellowish, jelly-like material is often very conspicuous during wet weather in spring and early summer. The telial mycelium is perennial, the teliospores being produced in spring and germinating immediately. The aecial stage develops slowly but dies during the summer. In many species the perennial mycelium produces distortions on the branches which are sometimes globular in shape. This has given the fungus the name of the "Cedar Apple Fungus."

GYMNOSPORANGIUM Sp.

A roestelia on the fruit of *Amelanchier* was collected at Walton, Lunenburg Co., by Miss Clara A. Corkum. (I am indebted to Prof. H. W. Smith of Truro for the specimens). It is doubtless the aecial stage of one of the species of *Gymnosporangium,* probably either *G. clavariaeforme* (Jacq.) D. C. or *G. germinale* (Schw.) Kern (*G. clavipes* C. & P.). Both of these species may have their aecial stage on the fruit of *Amelanchier* and the telial stage on *Juniperus nana* Willd.

MacKay (Trans. N. S. Inst. Science 11: 141, 1904) records *Roestelia lacerata* on the authority of Dr. John Somers and Prof. G. Lawson. This is the aecial stage of *G. clavariaeforme.* It is widely distributed in North America.

MacKay also records on the authority of Prof. G. Lawson *G. juniperi* Link. from Halifax Co., but gives no host. It may be, as the *Roestelia* and *Gymnosporangium* were collected at

the same place, that they were forms of the same species. The connection of the different forms was not well known, nor the nomenclature settled at the time of Prof. Lawson's collection. It may be that both collections belong to *G. clavariaeforme.*

GYMNOCONIA Lagerh.

Aecidia without peridium or enveloping paraphyses, dehiscing irregularly. Teliospores two-celled.

Only one species is known. It is found in North America and Europe.

Gymnoconia interstitialis (Schlect.) Lagerh.

0. Pycnia epiphyllous.

I. Aecia hypophyllous, occupying the whole surface of the leaf, large, irregular; peridium absent, epidermis rupturing irregularly, bright orange at first, appearing waxy. Aeciospores subglobose, elliptical or oblong, 15-27 by 25-40μ; wall thin, finely verrucose; contents orange, fading to colourless.

II. Uredinia wanting.

III. Telia hypophyllous, scattered, on irregular or brownish areas, very small, pulverulent, blackish-brown. Teliospores variable, often irregular, upper cell usually triangular, lower quadrangular or irregular; wall rather thin, uniform with papillae at germ-pores, smooth, chestnut-brown; pedicel hyaline, very slender, short, deciduous.

On *Rubus glandicaulis* Blanchard, Pictou, Truro.

This fungus is common on the species of blackberry named above. It was not collected on the more common large blackberry which has passed under the name of *Rubus villosus.* One collection of the aecial stage was parasitized by a species of *Tuberculina.*

Teliospores of *Gymnoconia interstitialis.*

In the United States this rust attacks the cultivated raspberries and blackberries and is known as the "orange rust." It does not seem to be troublesome in Nova Scotia.

The mycelium is perennial and thus the fungus can be successfully combatted only by destroying the infected plants.

PUCCINIA Pers.

Pycnia mostly subepidermal, sub-globose or flask-shaped, honey-coloured. Pycniospores very minute, globose or ellipsoid, hyaline.

Aecia mostly with well developed peridium, at first globose and closed, at length open, usually cup-shaped or cylindrical. Aeciospores arising in serial order, soon free, globose, subglobose or angular, hyaline, yellow or orange.

Uredina generally small, sometimes paraphysate. Urediniospores formed singly, usually with two or more germ pores, rarely one.

Telia variable in size, flattened or pulvinate, sometimes paraphysate. Teliospores free, on pedicels, two-celled (sometimes with one-celled spores mixed, rarely three-celled), one germ-pore in each cell. Basidiospores ovoid or reniform, mostly hyaline.

The genus *Puccinia* is a very large large one. Species belonging to this genus can usually be recognized by the two-celled teliospores. All the rusts that have been reported from Nova Scotia with two-celled teliospores belong to this genus except *Gymnoconia interstitialis,* the orange rust of the blackberry and raspberry.

Sydow in his monograph describes 1231 species. He includes the genera *Uropyxis* and *Diorchidium* as subgenera.

Arthur breaks up the genus into several genera, largely on the basis of the number of spore-forms present. *Tranzschelia* and *Polythelis* are separated because the teliospores are borne at the apex of a common stalk, and on other grounds. The majority of the species now included under *Puccinia* he places in the following four genera, which are separated by the spore-forms present as follows:

Life cycle with all the spore-forms............Dicaeoma.
Life cycle with pycnia, aecia and telia.........Allodus.
Life cycle with pycnia, uredinia and telia......Bullaria.
Life cycle with pycnia and telia.............Dasyspora.

Puccinia Hieracii (Schum.) Mart.

0. Pycnia not observed.

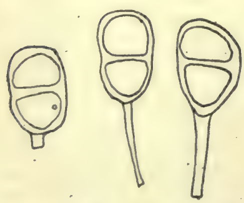
I. Aecia probably not formed.

II. Uredinia amphigenous, mostly epiphyllous, scattered, punctiform, soon naked, pulverulent. Urediniospores globose, subglobose or ellipsoid, 16-24 by 22-27μ; wall yellowish-brown, echinulate, pores 2.

III. Telia similar to the uredinia but elliptical to oblong on the stem and darker brown in colour. Teliospores ellipsoid or ovate-ellipsoid, 18-22 by 22-35μ, rounded at both ends, not or slightly constricted at the septum; wall brown, equally thickened, finely verrucose; pedicel delicate, hyaline, deciduous, mostly short but sometimes exceeding the spore.

On *Hieracium scabrum* Michx., Pictou; *H. canadense* Michx., Macdonald's Barren, C. B. (Collected by C. B. Robinson).

Formerly a number of species on *Compositae* which show little morphological differences were included under *P. Hieracii*. Jacky by cultures showed that infection from teliospores on *Hieracium* was confined to plants of this genus. This was also shown to hold for some other genera of the *Compositae*, that is teliospores from one genus of host plants could not infect a different genus. As a result of Jacky's work the rusts on the different genera of the *Compositae* are regarded as distinct.



Teliospores of *Puccinia Hieracii.*

The rust is not conspicuous but will doubtless be found to be common and generally distributed.

Puccinia Cichorii (DC.) Bell.

0. Pycnia not observed.

I. Aecia not known, probably not formed.

II. Uredinia amphigenous and caulicolous, scattered, minute, chiefly round, pulverulent, cinnamon. Urediniospores globose or subglobose, 22-27μ in diameter; wall light brown, echinulate.

III. Telia mostly caulicolous, oval, blackish-brown. Teliospores ellipsoid or ovate-ellipsoid, slightly or not constricted at the septum, 21-28 by 30-46μ, rounded at the apex and base; wall uniform, smooth, brown; pedicel hyaline, delicate, deciduous.

On *Cichorium Intybus* L., Durham, August 16, 1910.

This species does not seem to be common, as only one collection was made.

Puccinia obtegens (L.) Tul.

Puccinia suaveolens Lk.

0. Pycnia hycophyllous, at length covering the whole surface of the leaf

I. Aecia not formed.

II. Uredinia hypophyllous, at length amphigenous, scattered on upper, crowded on lower surface of leaf, pulverulent, dark brown. Urediniospores globose or subglobose, 25-30μ; wall light brown, echinulate, pores three.

III. Telia similar to the uredinia. Teliospores ellipsoid or ovate-ellipsoid, 18-22 by 32-35μ, rounded at both ends or base, slightly narrowed, not or slightly constricted at the septum; wall uniform, brown, slightly verrucose; pedicel slender, hyaline, deciduous, short.

On *Cirsium arvense* (L.) Scop., Pictou, Truro.

The rust on the Canada thistle is common and widely distributed. The life history of the fungus has been worked out by Rostrup. The mycelium hibernates in the upper part of the rootstock and thus the spring shoots are infected, the mycelium invading the plant. The first generation consists mostly of pycnia and uredinia, the second comes from urediniospore infection and the mycelium is localized. Urediniospores are freely produced but no pycnia.

The germ pore of the upper cell is placed at the apex; that of the lower cell is often some distance below the septum.

Puccinia variabilis Grev.

0. Pycnia not observed.

I. Aecia amphigenous, mostly hypophyllous, usually on small yellow or purple spots, solitary or in scattered small groups; peridium low, margin lacerate. Aeciospores subglobose or ovate, 18-22 by 22-27μ; contents orange, fading to colourless, verrucose.

II. Uredinia amphigenous, on small yellow or purple spots, scattered, small, soon naked, brown. Urediniospores globose, subglobose or ovoid, 18-20 by 20-27μ; wall brown, echinulate, pores 2.

III. Telia similar to the uredinia but dark brown. Teliospores ellipsoid or oblong-ellipsoid, 19-22 by 30-38μ, rounded at both ends, slightly or not constricted at the septum; wall thin, uniform, finely verrucose, dark brown; pedicel hyaline, slender, deciduous.

On *Taraxacum officinale* Weber, Pictou, French River.

According to Plowright two rusts are found on *Taraxacum* in Europe, *P. Taraxaci* with only the uredinial and telial stages and *P. variabilis* possessing an aecial stage as well. I have found the present species so closely associated with aecia

that there seems to be little doubt but that they are connected. Other collections on *Taraxacum* show no aecia. I have placed there under *P. Taraxaci* and the former are assigned here to *P. variabilis,* yet it seems probable that they belong to the same species. The aecia may only be produced under favourable conditions.

The germ-pore of the basal cell of the teliospore is usually placed low, not far from the pedicel; that of the upper cell is in the usual position near the apex.

The aecial stage of a sedge rust also occurs on *Taraxacum,* but has the aecia collected in large clusters, not scattered as in *P. variabilis.*

Puccinia Taraxaci (Rabent.) Plowr.

0. Pycnia not observed.

I. Aecia regarded as not formed.

II. Uredinia amphigenous, scattered, small, rounded, or oblong, pulverulent, brown. Urediniospores globose, subglobose or ovoid, 20-22 by 23-30μ, brown, echinulate.

III. Telia similar to the uredinia but blackish brown. Teliospores ellipsoid or ovate-ellipsoid, 19-22 by 25-35μ, rounded at both ends, little or not constricted at the septum; wall uniform, thin, finely verrucose, brown; pedicel hyaline, short.

On *Taraxacum officinale* Weber, Pictou.

This species differs from *P. variabilis* in the absence of the aecial stage. The germ pores of the urediniospores are two in number and are placed toward the apex.

Puccinia orbiculata Peck.

0. Pycnia amphigenous, few, in small groups on spots with the aecia.

I. Aecia hypophyllous and petiolicolous in groups on pale yellowish spots 1-3 mm. in diameter, hemispherical; peridium poorly developed. Aeciospores globose or ellipsoid, 17-20 by 20-30μ; wall pale yellowish, medium thick, densely and finely verrucose.

II. Uredinia amphigenous, on yellow or purple spots, scat ered, small punctiform, pulverulent, cinnamon. Urediniospores globose or subglobose, 22-27μ; wall yellow, finely echinulate.

III. Telia similar to the uredinia but dark brown. Teliospores ellipsoid, rounded at the base and apex, slightly constricted at the septum, 24-30 by 33-54μ; wall uniformly thin, finely but distinctly verrucose; pedicel hyaline, short, deciduous.

On *Prenanthes altissima* L., New Glasgow, Folleigh Lake.

This species occurs rather sparingly on its host, but is probably generally distributed.

Puccinia Onopordi Syd.

0. Pycnia not observed.

I. Aecia unknown, probably not formed.

II. Uredinia amphigenous, mostly epiphyllous, usually on pale yellowish spots, small, scattered, pulverulent, soon naked, surrounded by the ruptured epidermis, light brown. Urediniospores globose or subglobose or ellipsoid, about 27-39μ in diameter, or 24-30 by 27-35μ; wall brown, distinctly but sparsely echinulate with fine points.

III. Telia amphigenous, scattered on leaves, crowded and abundant on the stem, small and rounded on leaves, soon naked, mostly oblong on the stem and covered for some time by the epidermis, at length naked, pulverulent, dark brown. Teliospores variable in shape, often ellipsoid or oblong, 22-27 by 38-54μ; mostly rounded above, often narrowed toward the base, not or slightly constricted at the septum; wall uniform

except a low papilla where the germ pore emerges, finely punctate; pedicel hyaline, deciduous, shorter than spore.

On *Onopordon Acanthium* L., Pictou, New Glasgow, French River.

Sydow in his Monograph describes two new species of rusts on *Onopordon, Puccinia Onopordi* from Syria and *Puccinia Acanthi* from Germany, the latter differing from the former in having smaller teliospores. My collections have even larger teliospores than *P. Onopordi* and are therefore placed under that species.

Puccinia Bardanae Cda.

0 & I. Pycnia and aecia unknown, possibly wanting.

II. Uredinia amphigenous, scattered, rounded, pulverulent, cinnamon. Uredospores globose, subglobose or ellipsoid, echinulate, light brown, 26-30 by 22-27μ.

III. Telia amphigenous mostly hypophyllous, scattered, small, rounded pulverulent, blackish. Teliospores ellipsoid, apex not thickened, slightly constricted at the septum; wall dark brown, finely verrucose, 22-27 by 30-42μ; pedicel hyaline, short.

On leaves of *Arctium Lappa* L., Pictou.

This species does not seem to have been previously reported from North America. It was collected in only one place in the town of Pictou.

Puccinia Leontodontis Jacky.

0. Pycnia not observed.

I. Aecia probobly not formed.

II. Uredinia amphigenous, scattered, not confluent, small, punctiform, light brown. Urediniospores globose, subglobose or ellipsoid, 22-27 by 27-33μ, light brown, echinulate, germ-pores 2, in upper part of cell.

III. Telia similar to the uredinia but dark brown, variable, slightly ellipsoid, 20-30 by 27-41μ, rounded at both ends, slightly or not constricted at the septum; wall uniform, finely verrucose, chestnut-brown; pedicel, hyaline, short, deciduous.

Teliospores of *Puccinia Leontodontis.*

On *Leontodon autumnalis* L., Pictou.

This species is found in Europe, but it does not seem to have been previously reported in North America. It is common in the vicinity of Pictou.

Puccinia Solidaginis Peck.

0. Pycnia not observed.

I & II. Aecia and uredinia probably not formed.

III. Telia amphigenous, mostly hypophyllous on yellowish or purple spots, very small, mostly in groups, compact, brownish-black. Teliospores oblong or sub-clavate, 15-22 by 33-65μ, rounded above or acute, narrowed at the base, constricted at the septum; wall light brown, much thickened at the apex, up to 8μ, smooth; pedicel hyaline, persistent, about equalling the spore.

On *Solidago nemoralis* Ait. (?), Westwille, Sylvester; *Solidago puberula* Nutt., Pictou, August 24, 1910.

Puccinia bicolor E. & E.

0. Pycnia not observed.

I. Aecia probably not formed.

II. Uredinia not observed. Urediniospores mixed with the teliospores, mostly ovate, 16-18 by 27-35μ, pale yellowish, sparingly echinulate with rather large points.

III. Telia amphigenous, but mostly hypophyllous, small, thickly scattered over the under surface of the leaves, occupying all or part of a leaf, orbicular, rather compact, straw-yellow, becoming ochraceous. Teliospores oblong ellipsoid or clavate, rounded above or somewhat acute, usually narrowed toward the base, distinctly constricted at the septum, 13-20 by 28-45μ; wall hyaline or pale yellowish, smooth, thickened at the apex, 8μ or less; pedicel hyaline, firm, usually equally the spore or longer.

On *Hieracium scabrum* Michx., Pictou.

This species is probably distinct from *Puccinia bicolor,* but it is placed here for the present.

The telia develop early. They are evident by May 1 as small yellowish dots, and by the last week of May the teliospores are germinating, and continue developing till the last of June. Uredinia were present on some of the infected plants, but they seem to belong to *Puccinia Hieracii.* The infected leaves become elongated and yellowish in color, so that the rust is quite conspicuous.

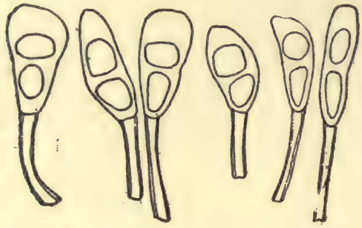
Puccinia Asteris Duby.

0. Pycnia not observed.

I & II. Aecia and uredinia not formed.

III. Telia mostly hypophyllous, on orbicular or irregular spots coloured yellow, brown or purple, mostly crowded, compact, brownish-black, surrounded by the ruptured epidermis. Teliospores clavate, 16-22 by 30-60μ, rounded or pointed above, narrowed toward the base, upper cell broaded, slightly constricted at the septum, wall dark brown, much thickened at apex, up to 12μ, smooth; pedicel nearly hyaline, rather broad, usually shorter than spore, sometimes longer.

On *Aster macrophyllus* L., Westville, Truro; *A. acuminatus* Michx., Folleigh Lake; *A. lateriflorus* (L.) Britton, Pictou.



Teliospores of *Puccinia Asteris.*

The teliospores on *Aster acuminatus* are slenderer than on *Aster macrophyllus.* The groups of telia are not so crowded nor so abundant on the former.

P. Asteris occurs on a number of asters. Morphological differences exist but they are not constant, so separation cannot be made on these grounds. Cultures alone can show whether more than one species are included.

Puccinia Cicutae Lasch.

0. Pycnia not observed.

I. Aecia on the nerves of the leaves more frequently on the petioles and stems, causing deformation, peridium poorly developed, not cup-shaped, breaking through the epidermis and rupturing irregularly. Aeciospores globose, sub-globose or ellipsoid, 15-22 by 20-27μ, subhyaline, finely punctate.

II. Uredinia amphigenous, mostly hypophyllous, small, scattered, circular, pulverulent, light brown. Urediniospores ovoid or ellipsoid, 20-24 by 20-30μ; wall pale brown, echinulate, pores 3.

III. Telia similar to the uredinia but larger and darker. Teliospores ellipsoid or oblong, 20-30 by 30-41μ, rounded at both ends, slightly constricted at the septum; wall much roughened, sometimes almost smooth, not thickened at the apex, brown; pedicel hyaline, slender, deciduous, up to 30μ, sometimes placed laterally on basal cell.

On *Cicuta maculata* L., Pictou, Piedmont.

This species is very common on its host in the districts near Pictou.

Sydow states that the aecial stage is rarely collected, the only collections being in Finland, Siberia and once in Germany. As this stage is conspicuous and not likely to be overlooked, he regards the aecia as not necessary for the fungus and only developed under favourable conditions.

A collections of the aecia was made near Pictou on July 3, 1909, in a shaded position. There was such a rich development that in some cases the host plants were killed.

Puccinia Thalictri Chev.

Polythelis Thalictri (Chev.) Arthur.

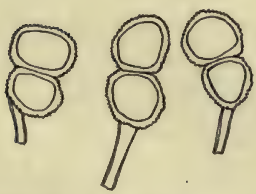
0. Pycnia hypophyllous, few, scattered among the telia.

I & II. Aecia and uredinia not formed.

III. Telia hypophyllous, scattered, never confluent, circular, 2-5 mm. across, soon naked, pulverulent, dark chestnut-brown, surrounded by the ruptured epidermis. Teliospores ellipsoid or oblong ovate, sometimes very irregular, much constricted at the septum, the cells separating easily, 15-30 by 22-52μ; walls dark brown, uniformly thickened, very coarsely and evenly verrucose; pedicel delicate, hyaline, about the length of the spore, deciduous.

On *Thalictrum polygonum* Var. *hebecarpum* Fernald, Truro, September 3, 1908; September 1, 1909; August 9, 1910.

Arthur places this species in the genus *Polythelis* on the basis of the teliospores forming heads by being attached by short pedicels to a common stalk, which is short and inconspicuous.



Teliospores of *Puccinia Thalictri*.

It seems to be rare, as it was found on only a few plants on the banks of the Salmon River near Truro, although search was made for it in other places. The fungus appears on the same plants each year and is for that reason regarded as perennial.

Puccinia Circaeae Pers.

0. Pycnia not observed.

I & II. Aecia and uredinia not formed.

III. Telia hypophyllous, on definite yellowish-brown or purple spots, about 2-3 mm. in diameter, small and crowded, pulvinate, at first yellowish, at length dark brown. Teliospores fusiform or oblong, 10-14 by 25-40μ, usually conical above and narrowed toward the base, slightly constricted at the septum; wall yellowish or light brown, much thickened at the apex, up to 8μ, smooth; pedicel hyaline, usually longer than the spore.

On leaves of *Circaea alpina* L., *C. lutetiana* L., Pictou.

Owing to the yellow or purple spots on the leaves, this rust is conspicuous. It is common in the districts about Pictou.

The telia formed late in the season differ from the earlier in being large and more elongated. The teliospores are similar in form, but the earlier are lighter in colour and germinate at once. The later are darker and germinate after wintering. Telia are formed also on the stem but my collections do not show this.

Puccinia Iridis (DC.) Wallr.

Uromyces Iridis DC.

0. Pycnia not observed.

I. Aecia not known, probably not formed.

II. Uredinia amphigenous, scattered, rounded or linear, long covered by the epidermis, at length naked, pulverulent, rusty-brown. Urediniospores globose, sub-globose, ellipsoid or ovate, 20-27 by 24-35μ; wall thick, yellowish-brown, echinulate.

III. Telia hypophyllous, scattered, linear, sometimes confluent, soon naked, black. Teliospores clavate or oblong, 14-22 by 30-52μ, rounded acuminate or truncate above, usually narrowed below, slightly constricted at the septum; wall light fuscous, darker and much thickened at the apex, up to 14μ, smooth; pedicel brownish, persistent, shorter than the spore.

On *Iris versicolor* L., Pictou.

The telial stage was not found although careful search was made for it in late autumn and early winter.

Sydow states that in some places only the urediniospores have been found, in other places teliospores and urediniospores may occur together, while in other places the teliospores are found only very late in the season.

Puccinia mesomegala B. & C.

0. Pycnia not observed.

I & II. Pycnia and aecia probably not formed.

III. Telia amphigenous, arranged in rows on pallid, circular or oval spots, about 5-8 mm. in diameter, spots sometimes coalescing, distinct, oval or circular, 150-320 by 150-450μ; ruptured epidermis conspicuous, ferruginous, pulverulent. Teliospores oval or oblong, rounded or pointed above, rounded or narrowed at the base, not or little constricted at the septum, 13-24 by 27-41μ; wall uniformly thin, light brown, sometimes with a small hyaline papilla at the apex and the side of the lower cell at the opening of the germ pore; pedicel hyaline, delicate, deciduous, equalling or shorter than the spore.

On *Clintonia borealis* (Ait.) Raf., Pictou, June 15, 1910.

Puccinia mesomegala was collected only in one place near Pictou. It is probably not common, as it is rather conspicuous.

Puccinia acuminata Peck.

Puccinia porphyrogenita Curt.

0. Pycnia not observed.

I & II. Aecia and uredinia probably not formed.

III. Telia hypophyllous, on brown or purplish often depressed spots, scattered, 1-3 mm. in diameter, surrounded by the ruptured epidermis, compact, black. Teliospores clavate.

oblong-clavate or oblong, 16-22 by 45-60μ, constricted at the septum, apex rounded or acuminate; wall dark brown, much thickened at the apex, 18μ or less, smooth; pedicel tinted, persistent, shorter than or equalling the spore.

On *Cornus canadensis* L., Pictou and Truro, (Prof. C. L. Moore.

Puccinia Acetosae (Schum.) Koern.

Puccinia Rumicis Lasch.

0. Pycnia not observed.

I. Aecia not known, probably not formed.

II. Uredinia amphigenous, mostly hypophyllous, scattered, small, rounded, pulverulent ferruginous. Urediniospores globose, ellipsoid or pyriform, 20-24 by 22-28μ, somewhat spiny, brownish.

III. Telia similar to the uredinia but oblong on the stem and dark brown. Teliospores ovoid, ellipsoid, oblong or subclavate, 19-26 by 30-46μ, rounded at both ends or slightly narrowed below, somewhat constricted at the septum; wall uniform, finely verrucose, chestnut-brown; pedicel hyaline slender, deciduous, up to 35μ long.

On *Rumex Acetosella* L., Pictou.

This rust was collected in one place near Pictou and this collection showed only a scanty development of urediniospores. Though search was made during the summer it was not found elsewhere. The rust is not conspicuous and may have been overlooked.

Puccinia Menthae Pers.

0. Pycnia in small groups, honey-coloured, conspicuous.

1. Aecia hypophyllous, on yellowish spots, sometimes purple, circinate. Aeciospores sub-globose or polygonal 16-25μ, verrucose, pale yellow.

II. Uredinia hypophyllous, small, on pale spots, roundish, surrounded by the ruptured epidermis, pulverulent, cinnamon-brown. Urediniospores sub-globose, ellipsoid or obovate, 18-22 by 22-27μ; wall thin or thick, echinulate, pores 2 or 3, equatorial.

III. Telia hypophyllous or caulicolous, scattered or aggregated, sometimes confluent, linear or oblong on the stem, rounded on the leaves, purverulent, blackish-brown. Teliospores ellipsoid or sub-globose, 22-27 by 27-35μ, rounded at both ends, a small hyaline papilla at apex, little or not constricted at the septum; wall chestnut-brown, smooth; pedicel slender, hyaline, usually much longer than the spore.

On *Mentha arvensis* Var. *canadensis* (L.) Briquet, Pictou, Piedmont.

Burril separated the American rust on the mints as Var. *americana* on the grounds that the teliospores are more strongly verrucose and more globose in shape. The collections from this vicinity agree more nearly with the European form, the teliospores being smooth.

The aecia are much less common than the other forms. A collection from Loch Broom, near Pictou, showed an abundant development of this stage, but the peridium had not opened when the collection was made. The infected plants grew in a shaded position.

The species is worldwide in its distribution, occurring on a large number of mints. It may be that several species are included in this one.

Puccinia Glaucis Arthur.

0. Pycnia not seen, probably obsolete.

III. Telia amphigenous, solitary or sometimes confluent in groups, 1.5-2 mm. across, roundish, 0.5-1 mm. in diameter, soon naked, pulvinate, compact, dark brown, becoming grey by germination of the spores, ruptured epidermis inconspicuous.

Teliospores lanceolate-oblong, 13-16 by 43-50μ, obtuse at both ends, slightly constricted at the septum; wall smooth, golden brown, rather thin, 1-1.5μ, obtusely thickened at the apex, 6-9μ; pedicel light yellow, slender, one-half to once length of spore.

On *Glaux maritima* L., Halifax.

I have not seen this species. The description is from the original one in the Bulletin of the Torrey Botanical Club, vol. 37, page 571, 1910.

Puccinia claytoniata (Schw.) Syd.

Puccinia Maria-Wilsoni Clinton.

0. Pycnia scattered among the aecia, orange.

I. Aecia hypophyllous, often petiolicolous or caulicolous, rarely epiphyllous, regularly scattered, often in crowded groups, occupying the whole surface of the leaf, low, rather wide, orange, margin subrevolute, laciniate. Aeciospores angular. sub-globose, 15-18μ, finely verrucose, orange.

II. Uredinia not observed.

III. Telia hypophyllous, often petiolicolous or caulicolous, rarely epiphyllous, irregularly scattered, small, rounded, surrounded by the ruptured epidermis, pulverulent, rufous brown. Teliospores irregular, usually ellipsoid or ellipsoid-oblong, rounded at both ends, 18-27 by 30-52μ; wall brown with a small lighter papilla at the apex, verrucose, not or little constricted at the septum.

On *Claytonia*, Three Brooks, Scotch Hill.

Specimens of *Claytonia* collected by Miss Isabella McCabe at Three Brooks showed a rich development of the aecial stage, especially on the stems and petioles, which were much deformed by the fungus.

Puccinia Violae (Schum.) DC.

0. Pycnia mostly epiphyllous, honey-yellow.

I. Aecia amphigenous, often deforming the petioles and leaves, in irregular clusters, low, margin recurved, lacerate. Aeciospores mostly sub-globose, 16-21 by 21-26μ, mostly 20-21μ in diameter, orange-yellow, fading to colourless, finely verrucose.

II. Uredinia hypophyllous or petiolicolous, scattered, small, rounded or elongate on the petiole, soon naked, pulverulent, cinnamon-brown. Urediniospores globose, sub-globose or ellipsoid, 18-22 by 20-28μ, dark brown, echinulate.

III. Telia hypophyllous or petiolicolous, often on yellowish spots, aggregated or scattered, small, rounded elongate on the petiole, pulverulent, dark brown or black. Teliospores ellipsoid or oblong-ellipsoid, 20-27 by 30-38μ, rounded at both ends, base sometimes narrowed, slightly or not constricted at the septum; wall chestnut-brown, somewhat thickened at the apex with a lighter papilla, usually smooth; pedicel deciduous.

On *Viola cucullata* Ait. and other *Viola* species, Pictou, French River.

The violet rust is very common in this vicinity.

Arthur and Holway (Minn. Bot. Studies 11, Part 5:631-641, 1901) in a paper on the violet rusts of North America state that this rust is common in its three forms, aecia, telia and uredinia, throughout North America on nearly all the indigenous species of the genus *Viola*.

Puccinia Polygoni-amphibii Pers.

Puccinia Amphibii Fuck.

P. Polygoni Alb. and Schw.

0 & I. On *Geranium maculatum* L.

II. Uredinia amphigenous, mostly hypophyllous, scattered or in circular groups, rounded, soon naked, pulverulent, yellow-

ish-brown. Urediniospores globose, ellipsoid or ovoid, 17-22 by 22-33μ; wall yellowish-brown, echinulate.

III. Telia hypophyllous, scattered or often arranged in circular groups, abundant, at length covering the under surface of the leaf, confluent, rounded on leaves, elongate on stem, remaining covered by the epidermis, blackish-brown. Teliospores clavate or oblong, 17-22 by 35-65μ, rounded, truncate or pointed above, mostly narrowed toward the base, slightly constricted at the septum, sometimes no constriction; wall dark brown, thickened at apex, about 7μ, smooth; pedicel hyaline or slightly coloured, usually shorter than the spore.

On *Polygonum amphibium* L., Pictou.

This rust was only found in one place at Cole's Pond near Pictou. It has a world wide distribution on *Polygonum* species. On some hosts the telia remain covered by the epidermis, in others they are soon naked.

Tranzschel was the first to show by cultures that the aecia on the wild geranium belonged to this rust. Arthur (Jour. Myc. 11:59. 1905) sowed the spores of *Aecidium sanguinolentum* Lindl. from *Geranium maculatum* on *Polygonum emersum* (Michx.) Britton and produced the uredinia and telia of this rust In the following year he sowed the teliospores from *Polygonum emersum* on *Geranium maculatum* and the aecia developed.

I have not found the aecial stage, nor even the host plant, in this vicinity.

Puccinia punctata Link.

Puccinia Galii Schw.

P. asperula Fuck.

0. Pycnia collected in small groups, honey-coloured.

I. Aecia hypophyllous, rarely caulicolous, on circular yellow spots, short cylindrical, margin recurved, whitish. Aeciospores globose or sub-globose, 17-22μ, orange-yellow, smooth.

II. Uredinia amphigenous, small, rounded or irregularly scattered, chestnut-brown. Unrediniospores globose, sub-globose or ellipsoid, 19-24 by 19-30μ; wall light brown, strongly echinulate.

III. Telia amphigenous, rounded on leaves, oblong or linear on stem, blackish, compact. Teliospores oblong or clavate, sometimes ellipsoid, 18-24 by 27-57μ, truncate or rounded above, sometimes conical, narrowed at base, slightly constricted at the septum; wall brown, much thickened at apex, smooth; pedicel coloured, persistent, thickened, usually shorter than the spore.

On *Galium asprellum* Michx., New Glasgow.

A collection on July 22 showed the aecia past their prime and uredinia beginning to appear; another on August 26 showed telia developed on the leaves and stem. This rust was only found in one place so that it does not appear to be common.

Puccinia graminis Pers.

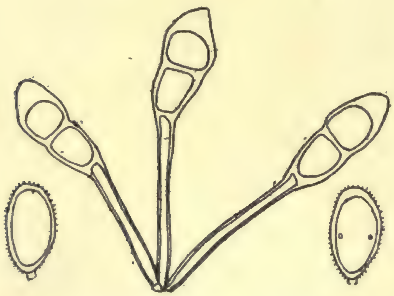
Puccinia poculiformis (Jacq.) Wettst.

0. Pycnia in small groups, honey-yellow.

I. Aecia hypophyllous, usually in small groups on discoloured spots, cylindrical, margin white, erect, more or less incised. Aeciospores angular-globose, orange-yellow, becoming pale yellow, 14-16μ; wall thin, smooth.

II. Uredinia amphigenous, often on culms and sheaths, scattered or grouped, oblong or linear, soon naked, pulverulent, ferruginous, surrounded by the ruptured epidermis. Urediniospores elliptic-oblong or obovate, 14-22 by 19-38μ, brownish-yellow, becoming yellowish, echinulate, pores usually four, equatorial.

III. Telia amphigenous, mostly on culms, sheaths and infloresence, oblong or linear, often confluent, black, soon naked, surrounded by the ruptured epidermis, pulvinate. Teliospores oblong-clavate, oblong-fusiform, narrowly obovate or sometimes ellipsoid, 16-22 by 22-68μ; apex rounded, obtuse or conical, base narrowed, sometimes rounded, usually somewhat constricted at the septum; wall chestnut-brown, apex darker, thickened 8-10μ, smooth; pedicel coloured, firm, usually as long as the spore, sometimes short.



Teliospores of *Puccinia graminis.*

Aecia on *Berberis vulgaris* L. (cultivated), Truro.

Uredinia and telia on *Agropyron vulgare* L., *A. repens* Beauv., *Avena sativa* L., *Agrostis alba* L., Pictou, Truro; *Hordeum jubatum* L., Pictou; *Secale cereale,* Truro.

Puccinia graminis is found on a large number of grasses. By infection experiments Ericksson showed that it consists of a number of specialized forms, all having their aecia on the barberry, but nevertheless not capable of infecting one another. As a result of experiments so far conducted, the following forms have been indicated:

1. *Secalis,* on Rye (*Secale cereale*) and other hosts.
2. *Avenae,* on Oats (*Avena sativa*).
3. *Airae,* on *Airia.*
4. *Agrostidis,* on *Agrostis.*
5. *Poae,* on *Poa.*
6. *Tritici,* on Wheat (*Triticum vulgare*).

Arthur (Mycol. 2:227. 1910) states that, though in the uredinial stage this rust shows racial strains that inhibit the ready transfer from one species of host to another, yet in the aecial stage racial strains play no part, and the barberry acts as a bridging host between each and every other gramineous host.

Puccinia phlei-pratensis Erikss. and Henn.

0 & I. Pycnia and aecia unknown.

II. Uredinia amphigenous, mostly epiphyllous, on the stem linear and breaking through the epidermis by a lateral fissure, on the leaves scattered, small and oblong, pulverulent, yellowish-brown. Urediniospores ellipsoid, oblong-ellipsoid or obovate, 16-21 by 24-32μ; wall dull yellow, echinulate.

III. Telia similar to the uredinia but blackish-brown, mostly on the stem. Teliospores mostly elongate, 16-20 by 35-48μ, rounded or somewhat acute above, narrowed toward the base, slightly constricted at the septum; wall chestnut-brown, thickened at the apex, usually 5-8μ, smooth; pedicel persistent, strongly tinted, thickened, usually longer than the spore.

On *Phleum pratense* L., Pictou.

In 1894 Ericksson and Henning separated the timothy rust as a distinct species, on the ground that it does not form its aecial stage on the barberry. Previously it was considered as identical with *Puccinia graminis,* from which it cannot be separated on morphological grounds. Kern (Torreya 9: 3, 1909) points out that in Eriksson and Henning's original report, out of nine trials to infect the barberry with teliospores of the timothy rust one was successful and eight were failures. He thinks that more weight ought to be given to the one positive result than to all the failures, and concludes that the timothy rust may be considered a race or physiological species

of *Puccinia graminis.* Arthur (Mycologia 1:231. 1909) reports several unsuccessful trials to infect the barberry with this rust, nevertheless he expresses his agreement with Kern's conclusions.

This rust has only recently attracted attention in North America. It seems to be rapidly increasing. I have found it rather common on timothy growing by the roadsides and in shaded places in fields. Here both the uredinial and telial stages are developed, the latter appearing late in the fall. The uredinial stage was common on the after-grass in hay-fields about Pictou. It may yet do a considerable amount of injury to the hay crop, but probably will not be sufficiently developed before the hay is harvested to do serious damage.

Puccinia Lolii Neils.

Puccinia coronifera Kleb.

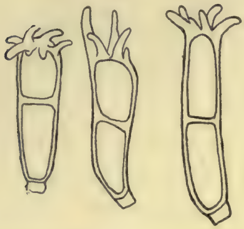
0 & I. Pycnia amphigenous, usually in small groups, sometimes abundant, on the spots bearing aecia, honey-coloured.

I. Aecia hypophyllous or peticolous, on yellowish or yellowish-purple spots, causing distortion of the petioles, cylindrical, rather low, margin whitish, lacerate, revolute. Aeciospores irregular, globose, about 19-25μ; wall colourless, finely verrucose; contents orange.

II. Uredinia amphigenous, oval or linear, pulverulent, orange. Urediniospores globose, sub-globose or ovate, 16-24 by 20-30μ; wall orange, echinulate, pores 3 or 4, sometimes a few colourless, capitate paraphyses present.

III. Telia hypophyllous, oblong or linear, often confluent and crowded, long covered or remaining covered by the epidermis, black. Teliospores elongated clavate, 16-22 by 33-70μ, tapering toward the base, apex truncate with irregular, blunt, curved processes, variable in size and shape, not or

slightly constricted at the septum; wall yellowish-brown or brown ,thickened at the apex, smooth; pedicel short, thickened, coloured, persistent.



Teliospores of *Puccinia Lolii.*

Pycnia and aecia on *Rhamnus cathartica* L., Pictou.

Uredinia and telia on *Avena sativa* L., Pictou, Truro.

This rust is very common on the cultivated oat. It is found chiefly on the leaves. It is much more common in this vicinity than *Puccinia graminis.* Both are often found occurring on the same plant, *P. Lolii* on the leaves, and *P. graminis* chiefly on the stems and sheaths.

Culture experiments have shown the following form species:

1. *Avenae* on *Avena sativa.*
2. *Alopecuri* on *Alopecurus pratensis.*
3. *Festucae* on *Festuca elatior.*
4. *Lolii* on *Lolium perenne.*
5. *Glyceriae* on *Glyceria aquatica.*
6. *Holci* on *Holcus lanatus* and *H. mollis.*

Puccinia coronata Cda.

Puccinia Rhamni (Pers.) Wettst.

0 & I. Pycnia and aecia on *Rhamnus alnifolia.* (Not collected).

II. Uredinia hypophyllous, scattered or arranged in lines, sometimes confluent, small, more or less oblong, pulverulent, orange. Urediniospores globose, sub-globose or ovate, 16-24 by 20-30μ, echinulate, yellow, pores 3 or 4, paraphyses present.

III. Telia hypophyllous or caulicolous, scattered, sometimes in long lines on the stem, sometimes confluent, oblong or linear, covered for a long time by the epidermis, at length

naked, black. Teliospores oblong or clavate, 16-22 by 38-68μ, apex with projections, erect or inclined, often crown-like, base narrowed; wall thin, thickened somewhat at apex, brown, darker at apex; pedicel short, thickened, sometimes absent.

On *Calamagrostis canadensis* (Michx.) Beauv., Pictou.

The aecia of this species is on *Rhamnus alnifolia* L'Her.

Puccinia coronata Corda was the name formerly given to the species occurring on oats (*Avena sativa*) and other grasses, with teliospores provided with a crown of processes and called the crown rust. Klebahn, by culture experiments, found that teliospores from some of these grasses produced aecia only on *Rhamnus frangula*, while teliospores from others produced aecia only on *Rhamnus cathartica*. This showed that two species were included under *P. coronata*. Klebahn gave the name *P. coronifera* to the rust producing aecia on *Rhamnus cathartica* and the original name was retained for the rust producing its aecia on *Rhamnus frangula*. Later, on the basis of priority, the name *P. Lolii* Neils has replaced Klebahn's *P. coronifera*.

Ericksson has shown that this species, *P. coronata* Corda, as limited by Klebahn, consists of several biological forms:

1. *Calamagrostidis.*
2. *Phalaridis.*
3. *Agrostidis.*
4. *Agropyri.*
5. *Holci.*
6. *Epigaei.*

Arthur sowed teliosporic material, part of the Pictou collections, on *Rhamnus frangula* with abundant infection. (See Arthur Mycologia 4:18. 1912).

Puccinia Maydis Béreng.

Puccinia Sorghi Schw.
Puccinia Zeae Rabh.

0 & I. Pycnia and aecia on *Oxalis corniculata* L. (Not collected in Nova Scotia).

II. Uredinia amphigenous, scattered or aggregated, elliptical or oblong, long covered by the epidermis, ruptured epidermis prominent, yellowish-brown. Urediniospores globose, sub-globose or elliptical, 24-28 by 27-33μ, wall yellowish-brown, finely and sparingly echinulate, pores 4, scattered.

III. Telia amphigenous, scattered or somewhat gregarious, linear or oblong, long covered by the epidermis, at length naked, compact, black. Teliospores oblong, ellipsoid or obovate, 16-24 by 27-41μ, rounded or obtuse, rarely somewhat acute, base rounded or slightly narrowed, slightly constricted at the septum; wall golden-brown, moderately thickened at apex, about $2\frac{1}{2}\mu$, smooth; pedicel tinted, thickened, persistent, usually about the length of the spore or somewhat longer.

On *Zea mays* L., Lower Mount Thom.

In 1904 Arthur (Jour. Myc. 11:65. 1905) sowed aeciospores from *Oxalis corniculata* L. on young corn plants and produced the uredinia and telia of this rust. In the following year (Jour. Myc. 12:17. 1906) he sowed the teliospores from the corn on *Oxalis corniculata* L. and aecia followed. Kellerman (Jour. Myc. 12:10. 1906) confirmed the last result, producing aecia on *Oxalis corniculata* by sowing the teliospores from corn.

The specimens in my herbarium were collected by Prof. C. L. Moore.

Puccinia triticina Erikss.

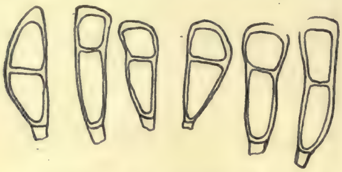
Puccinia Rubigo-vera (DC.) Winter.

Puccinia Rubigo-vera Var. *Tritici.*

0 & I. Pycnia and aecia unknown.

II. Uredinia amphigenous, mostly epiphyllous, scattered, oblong, small, ferruginous. Urediniospores globose or subglobose, 20-27μ, sparingly echinulate, yellow.

III. Telia hypophyllous (or culmicolous), scattered, oblong, covered by the epidermis, black. Telia oblong-clavate or clavate, 15-20 by 35-48μ, apex rounded, truncate or sometimes obliquely pointed, slightly constricted at the septum, base narrowed; wall thin, brown, slightly thickened at the apex; pedicel short, coloured; paraphyses brown, numerous.



Teliospores of *Puccinia triticina.*

On *Agropyron vulgare*, Pictou.

This rust on wheat, which can be easily separated from *P. graminis* by its covered telia, was found to be rather common in this vicinity. It may not be identical with the European species, but, until culture experiments have been tried, may be placed here provisionally.

Formerly the rusts on wheat and other grasses, which are characterized by the presence of paraphyses among the teliospores, and the telia remaining covered for a long time by the epidermis, were regarded as one species, *Puccinia Rubigo-vera* (D. C.) Winter. Eriksson and Henning in 1896 divided this species into two on the grounds of differences in the uredinia, *P. glumarum* with bright orange uredinia arranged more or less in rows, and *P. dispersa* Erikss. with chocolate-brown uredinia more or less scattered over the leaves.

Infection experiments have shown the following specialized forms in *P. glumarum*:

1. *Tritici.*
2. *Hordei.*
3. *Elymi.*
4. *Agropyri.*
5. *Secalis.*

From *Puccinia dispersa* Erikss. a number of biological species have been separated by infection experiments, so that

the former *P. dispersa* Erikss. now consists of the following species:

P. dispersa Erikss. on rye (*Secale cereale*). Aecia on *Anchusa* species.

P. triticina Erikss. on wheat (*Triticum*). Aecia unknown.

P. bromina Erikss. on brome grass (*Bromus*). Aecia on *Symphtum officinale* and *Pulmonaria montana.*

P. agropyrina Erikss. on coach grass (*Agropyron repens*). Aecia unknown.

P. holcina Erikss. on *Holcus* species. Aecia unknown.

P. Triseti Erikss. on *Trisetum flavescens.* Aecia unknown.

Puccinia agropyrina Erikss.

0 & I. Pycnia and aecia unknown.

II. Uredinia mostly epiphyllous, scattered, small or medium sized, oval or oblong, rusty yellow. Urediniospores globose or sub-globose, 20-27μ, finely echinulate; wall pale yellow; contents yellow.

III. Telia mostly hypophyllous, often on the sheaths, scattered or sometimes aggregated, oblong, covered by the epidermis, black. Teliospores oblong or oblong-clavate, 14-21 by 40-54μ, rounded or obtuse at apex, narrowed toward base, not or slightly constricted at the septum, smooth, brownish; pedicel short, coloured; paraphyses present.

On *Agropyron repens* L., Pictou.

This rust is very common on its host near Pictou, especially on the after-grass in hay-fields. Both the uredinial and telial stages were found abundantly in late fall.

This species may not be identical with the European rust on *Agropyron repens,* but it is placed here provisionally, or until infection experiments decide its position. It may be *P. obliterata* Arth., which has aecia on *Thalictrum* and *Aquilegia.* (Arthur, Mycologia 1:250. 1909; 2:225. 1910).

Puccinia perplexans Plowr.

0. Pycnia not described.

I. Aecia hypophyllous or petiolicolous, on rounded yellow spots, in elongate or rounded groups, cup-shaped or cylindrical, margin white, incised. Aeciospores angular-globose, finely verrucose, orange, 18-27μ in diameter.

II, Uredinia chiefly epiphyllous, scattered, chiefly oblong or linear, yellowish brown. Urediniospores sub-globose or ovate, 16-20 by 19-27μ; wall rather thick, pale yellowish, echinulate.

III. Telia chiefly hypophyllous, scattered, small, oblong or linear, about 1-1½ mm. long, covered by the epidermis, blackish. Teliospores mostly oblong-clavate or clavate, apex rounded, truncate, rounded or obliquely conical, somewhat thickened at the apex, slightly constricted at the septum, 16-24 by 36-60μ; wall brown, darker above, smooth, thickened somewhat at the apex; pedicel very short.

Pycnia and aecia on *Ranunculus acris* L., Pictou, June, 1911.

Uredinia and telia on *Alopecurus pratensis* L., Pictou.

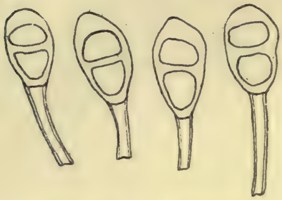
This species does not seem to have been previously collected in North America. Cultures by the writer confirmed what had already been established by European investigators, that the aecia are produced on *Ranunculus acris* L. (See Mycologia 4:179. 1912).

Puccinia anthoxanthi Fuck.

0 & I. Pycnia and aecia unknown.

II. Uredinia amphigenous, mostly epiphyllous, on indefinite yellow spots, scattered or aggregated, elliptical or linear, soon naked, small, yellowish-ferruginous, capitate paraphyses present. Urediniospores mostly ovate or obovate, 18-22 by 23-33μ, finely echinulate, yellowish.

III. Telia amphigenous, scattered, small oblong or linear, soon naked, blackish-brown. Teliospores elliptical, sub-clavate or oblong, 18-22 by 25-40μ, apex mostly rounded, base rounded or narrowed; wall chestnut-brown, thickened at apex, smooth; pedicel persistent, coloured, usually shorter than spore.



Teliaspores oi *Puccinia anthoxanthi*

On *Anthoxanthum oderatum* L., Pictou.

Sydow does not report this species from North America, nor has it been reported as far as I am aware. It was found in only one place near Pictou in 1909 and 1910.

Puccinia tomipara Trel.

0. Pycnia epiphyllous, in small groups, honey-yellow, punctiform.

I. Aecia hypophyllous, in orbicular groups, crowded; peridium somewhat low, margin slightly revolute, erose. Aeciospores globoid, 20-25μ; wall thin, colourless, verrucose.

II. Uredinia epiphyllous, scattered, rounded or oblong, small cinnamon. Urediniospores globose or sub-globose, 22-27μ, echinulate, yellowish-brown.

III. Telia epiphyllous, mostly oblong, remaining covered by the epidermis, compact, black. Teliospores oblong or oblong-clavate, 16-24 by 35-54μ ,mostly truncate at the apex, sometimes rounded or acute, narrowed below, not constricted at the septum; wall chestnut-brown, somewhat thickened at the apex, smooth; pedicel very short.

Aecia on *Clematis virginiana* L., New Glasgow, July 6, 1909.

Telia on *Bromus ciliatus* L., Truro, Sept., 1908, 1909.

The collections do not show uredinia. They probably had disappeared before the collections were made.

The connection of the aecial stage was shown by cultures in 1904 by Arthur. (Jour. Myc. 11:62. 1905). He confirmed these results by later cultures.

Puccinia perminuta Arth.

0 & I. Pycnia and aecia unknown.

II. Uredinia not collected.

III. Telia mostly hypophyllous, rounded, oval or chiefly linear. dark brown, remaining covered by the epidermis. Teliospores variable, usually oblong, truncate or rounded at the apex, sometimes narrowed toward the base, 10-16 by 30-50μ; wall brown, rather thin except at the apex, there much thickened, 10μ or less; pedicel very short.

On *Agrostis alba* L., Pictou, August, 1910.

Only telia were present in the collections of this rust, and no description of the uredinia is at hand. The determination was made by F. D. Kern.

Puccinia obscura Schroet.

0 & I. Pycnia and aecia on *Bellis perennis* L. (Europe).

II. Uredinia amphigenous, mostly hypophyllous, on irregular yellowish spots, scattered or irregularly distributed, elliptical or oblong, covered for some time by the epidermis, at length naked, pulverulent, yellowish-brown. Urediniospores sub globose, ellipsoid or obovate, 20-25 by 27-35μ; wall rather thick, brown, strongly but sparingly echinulate.

III. Telia similar to the uredinia but more compact. Teliospores oblong or clavate, 16-20 by 30-48μ, rounded above, sometimes rather acute, base narrowed, constricted at the septum, cells separating easily; wall pale yellowish-brown, somewhat thickened at the apex, about 3-5μ, smooth; pedicel mostly hyaline, usually shorter than the spore.

On *Luzula campestris* Var. *multiflora* (Ehrk.) Celak., New Glasgow; *L. saltuensis* Fernald, New Glasgow, French River, Truro.

The uredospores appear in early spring, so that it is very probable that the mycelium is perennial, as the leaves of the host remain green during the winter.

Plowright worked out the life history of this rust showing that the aecial stage is on *Bellis perennis.* No cultures have been made to establish the identity of the American and European rusts.

Puccinia cinerea Arth.

0 & I. Pycnia and aecia on *Ranunculus cymbalaria* Pursh.

II. Uredinia mostly caulicolous, sometimes on the leaves, linear, 1 mm. or less, ferruginous, pulverulent, ruptured epidermis evident. Urediniospores oval or obovate, 18-23 by 27-33μ; wall colourless, medium thick, very finely echinulate; contents orange-yellow.

III. Telia amphigenous and caulicolous, linear, remaining covered by the epidermis, blackish. Teliospores clavate, oval, or oblong, rounded, truncate or narrowed at the apex, chiefly narrowed at the base, slightly or not constricted at the septum, 16-23 by 32-50μ; wall yellowish-brown or dark brown, slightly thickened at the apex, smooth; pedicel short, tinted, persistent.

Pycnia and aecia on *Ranunculus cymbalaria* Pursh., Pictou.

Uredinia and telia on *Puccinellia maritima* (Huds.) Parl., Pictou, September, 1910.

Arthur (Mycologia 1:246. 1909) by infection experiments showed that *Puccinia cinerea* has its aecial stage on *Ranunculus cymbalaria.*

Puccinia Sambuci Arth.

0. Pycnia amphigenous, mostly epiphyllous, in small groups on the aecia bearing spots, honey-yellow.

I. Aecia hypophyllous, on rounded yellow, often bullate spots, in circular groups of different sizes, irregular shaped on the nerves, margin recurved, incised. Aeciospores angular-globose, about 16-19μ, finely verrucose, yellowish.

II. Uredinia hypophyllous, rounded, elliptical or linear, surrounded by the ruptured epidermis, pulverulent, cinnamon. Urediniospores sub-globose or obovate, about 22μ in diameter, echinulate, yellowish-brown.

III. Telia hypophyllous, rounded or oblong, scattered or gregarious and confluent, surrounded by the ruptured epidermis, pulvinate, blackish-brown. Teliospores oblong-clavate, 18-24 by 38-52μ, rounded or obtuse above, narrowed below, constricted at the septum; wall light brown, much thickened above, 5-10μ, smooth; pedicel persistent, hyaline, usually shorter than spore.

Pycnia and aecia on *Sambucus canadensis* L., Pictou.

Uredinia and telia on *Carex lurida* Wahlenb., Pictou.

The aecial stage was common on its host near Pictou. Only one collection of the rust on *Carex lurida* was made. It differs somewhat from Sydow's description. The teliospores are smaller and the pedicels shorter, but it is placed here provisionally. It may be that some other common *Carex* rusts belong to this species

Puccinia Opizii Bubak.

0. Pycnia numerous, on the spots with the aecia, dark honey-yellow.

I. Aecia hypophyllous or culmicolous on purplish or reddish circular spots surrounded by a more or less extensive yellowish zone, spots ½ to 1½ cm. in diameter, in groups occupy-

ing the whole of the spot, cup-shaped or short cylindrical, law, margin white, revolute, lacerate. Aeciospores globose, sub-globose or ellipsoid, about 16-18μ in diameter, verrucose, orange.

II. Uredinia hypophyllous, in small yellowish spots, scattered, minute, ovate or oblong, at first covered by the epidermis, at length naked, pulverulent, brown. Urediniospores globose, sub-globose or ellipsoid, 17-22 by 18-33μ, remotely echinulate, brown, pores two.

III. Telia hypophyllous or culmicolous, scattered or aggregated, small, ovate or oblong, long covered by the epidermis, pulvinate, black. Teliospores clavate or oblong-clavate, 13-24 by 35-60μ, apex rounded, truncate or long conical, base narrowed, slightly constricted at the septum; wall yellowish-brown, much thickened and darker at apex, smooth; pedicel hyaline, persistent, equalling the spore.

Pycnia and aecia on *Lactuca spicata* (Lam.) Hitchc. and Var. *integrifolia* (Grey) Britton; *L. canadensis* L., Pictou.

Uredinia and telia on *Carex muricata* L., (Europe). (Not collected in Nova Scotia).

Arthur (Jour. Myc. 13:194. 1907) produced what he regards as the aecia of this rust on *Lactuca* from the teliospores of an undetermined *Carex*. Bubak had previously worked out the connection for the European rust by cultures. The aecia are so characteristic that there is little doubt that they belong to this species, and that the telial form on *Carex* will yet be found.

Puccinia Caricis-Asteris Arth.

0. Pycnia epiphyllous, in small groups on the spots that bear the aecia.

I. Aecia hypophyllous, usually grouped on yellowish spots, cup-shaped or cylindrical, low, margin revolute, lacerate. Aeciospores angular globose, about 13-16μ; wall colourless, finely verrucose; contents yellow.

II. Uredinia hypophyllous, oblong. Urediniospores ovate, echinulate, 14-17 by 17-22μ; wall thin, brownish.

III. Telia hypophyllous, oblong or linear, soon naked, surrounded by the ruptured epidermis, dark brown or blackish. Teliospores oblong or oblong-clavate, apex mostly rounded, much thickened, 16-21 by 37-60μ; pedicel tinted, shorter than or equalling the spore.

Puccinia and aecia on *Aster acuminatus* Michx. and other *Aster* species, Pictou.

Uredinia and telia on *Carex trisperma* Dewy, and probably on other *Carex* species, Pictou.

The writer established by cultures that the *Puccinia* on *Carex trisperma* has aecia on *Aster acuminatus.* It is probable that a number of other collections on *Carices* belong to this species. That on *Carex canescens* Var. *disjuncta* Fernald is probably included here.

Puccinia Caricis-Solidaginis Arthur.

0 & I. On *Solidago graminifolia* (L.) Salisb. and other species of *Solidago,* Pictou.

II. & III. Uredinia and telia on *Carex scoparia* Schk. and *C. stipata* Muhl., Pictou.

There does not seem to be any marked morphological differences between the forms of this species and *Puccinia Caricis-Asteris* so that a description is not given.

Cultures by the writer established the connection of the above forms for this region. (See Mycologia 4:181. 1912). It is probable that other collections of *Puccinia* on sedges in this vicinity belong to this species.

Puccinia caricina DC.

On *Carex Deweyana* Schwein., *C. paupercula* Michx., *C. stellulata* Good., *C. stellulata* Var. *cephalantha* (Bailey)

Fernald, *C. tenella* Schkuhr., *C. canescens* Var. *disjuncta*, Pictou.

These rusts are placed under this species provisionally until their position is determined by cultures. Some of them may belong to *Puccinia Caricis-Solidaginis* Arth. which has aecia on *Solidago* species; probably some belong to *P. Caricis-Asteris* Arth., while others may have their aecia on *Ribes*. Culture work is necessary before many of the rusts so common on the sedges can be assigned to their proper species.

Puccinia angustata Peck.

0. Pycnia epiphyllous, in small groups on the spots bearing aecia.

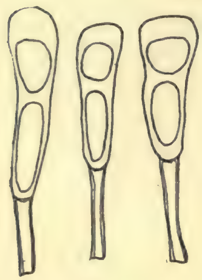
I. Aecia hypophyllous or caulicolous, on yellow, brown or brownish-purple orbicular spots, in small dense groups on the spots, in irregular, larger groups on the stem and petioles, cylindrical, cup-shaped, margin recurved, incised, white. Aeciospores globose or angular-globose, 16-20μ, verrucose, pale yellowish.

II. Uredinia hypophyllous, often on yellowish areas, mostly arranged in lines, oblong or linear, long covered by the epidermis, pulverulent, light brown. Urediniospores subglobose, ellipsoid or obovate, 18-22 by 26-31μ, wall strongly but sparingly echinulate, yellowish-brown.

III. Telia similar to the uredinia but black and rather compact. Teliospores clavate or fusoid-clavate, 16-22 by 43-73μ, apex truncate, rounded or acuminate, base narrowed, slightly constricted at the middle; wall pale brown, much thickened, up to 14*u*, and darker at apex, smooth; pedicel light brown, thickened, persistent, usually a little shorter than spore.

Aecia on *Lycopus americanus* L., *L. uniflorus* Michx., Pictou.

Uredinia and telia on *Scirpus cyperinus* (L.) Kunth., *S. rubrotinctus* Fernald, Pictou.



Teliospores of *Puccinia angustata.*

The aecial stage on *Lycopus* and the uredinial and telial on *Scirpus* are very common and usually found closely associated. The aecia appear in the early part of July. Arthur worked out the connection between the stages in 1899 (Bot. Gaz. 29:273. 1900) and has confirmed his results several times. (Jour. Myc. 8:53. 1902; 11:58. 1905; 13:196. 1907; 14:14. 1908; Mycologia 1:234. 1909).

It may be that the collections on *Scirpus rubrotinctus* represent a distinct species.

Puccinia albiperidia Arth.

0. Pycnia amphigenous, small, pale orange.

I. Aecia hypophyllous, small, in somewhat circular clusters, substratum scarcely thickened; peridia white, low, margin incised, reflexed. Aeciospores pale yellow when fresh, sub-globose, 15-20μ in diameter; wall thin, smooth.

II. Uredinia hypophyllous, small, round or oblong, soon naked. Urediniospores oblong, small, echinulate.

III. Telia hypophyllous, globose or oblong, pulvinate, dark brown. Teliospores oblong-cuneate, apex rounded or obtuse, thickened at apex, slightly or not constricted at the septum, 17-24 by 31-45μ; pedicel slender, coloured, as long as the spore or longer.

Aecia on *Ribes oxyacanthoides* L., *R. prostratum* L'Her., Pictou.

Uredinia and telia on *Carex crinita* Lam., *C. intumescens* Rudge, *C. pallescens* L., *C. debilis* Vr. *Rudgei* Bailey, C. *arctata* Boott., Pictou.

The limits of this species are not known at present. It may be that more than one species is represented in the collections assigned here. Possibly some of them belong to *Puccinia Grossulariae* (Schum.) Arth.

The collections on the *Carex* species assigned here were shown by the cultures of the writer to have their aecial stages on *Ribes*. (See Mycologia 4:180. 1912). Probably several other collections on *Carex* species also belong to this rust. But cultures are necessary before the relation of many of the rusts on the genus *Carex* can be ascertained.

Puccinia Eleocharis Arth.

0. Pycnia epiphyllous.

I. Aecia hypophyllous, grouped on yellow spots 3-4 mm. in diameter, cylindrical, cup-shaped, low, margin revolute, lacerate. Aeciospores mostly angular-globose or sub-globose, about 14-18μ, hyaline, verrucose.

II. Urediniospores mixed with the teliospores, irregularly globose or ovoid, finely and sparsely echinulate, yellowish.

III. Telia scattered or subgregarious, sometimes confluent, small, rounded, remaining covered for a long time by the epidermis which at length ruptures, sometimes black. Teliospores oblong, rounded or obliquely subtruncate, 16-21 by 45-54μ, apex moderately thickened, not or slightly constricted at the septum; base rounded or often somewhat narrowed, smooth, dark brown; pedicel thickened, very short.

Pycnia and aecia on *Eupatorium perfoliatum* L., Pictou.

Uredinia and telia on *Eleocharis intermedia* (Muhl.) Schultes, *E. palustris* (L.) R. & S. (not collected).

The aecial stage was found in only one place near Pictou. The telial stage on *Eleocharis* was not collected, but as the host plants are common and as the rust has been collected in Maine, it probably occurs in Nova Scotia. As the rust is inconspicuous it may easily be overlooked.

Arthur (Jour. Myc. 12:23. 1906) by cultures showed the connection of the aecia on *Eupatorium* and has confirmed this result by recent cultures. (Jour. Myc. 13:193. 1907; Mycologia 1:233. 1909).

Form Genera.

These are imperfect forms, which occur in only one stage and cannot be assigned to their proper genera till the complete life cycle is known. It is convenient to assign them to form genera till their true position is determined. The forms included here are *Uredo, Caeoma, Aecidium, Peridermium* and *Roestelia.*

Uredo.

Uredo forms are uredinia that have not been connected with their telial form. They have the characteristics of the uredinial stages of the *Pucciniaceae.* It is possible that some possess perennial mycelium so that they can dispense with teliospores, or that the urediniospores may carry the fungus over the winter. I have not collected any of them in Nova Scotia.

Aecidium.

Peridium present, usually cup-shaped, spores in chains. Forms placed here are simply the aecial stages of unconnected rusts. The form genus *Peridermium* is sometimes included.

Aecidium Compositarum Var. Solidaginis.

0. Pycnia amphigenous, in small groups on the spots that bear the aecia, inconspicuous.

I. Aecia chiefly hypophyllous, on yellow spots or areas, cylindrical or cup-shaped, low, margin lacerate. Aeciospores angular-globose or ellipsoid, about 15-19μ; wall colourless, finely verrucose; contents yellowish, becoming colourless.

On *Solidago canadensis* L., *S. rugosa* Mill., Pictou.

These collections are probably the aecial stage of *Puccinia Caricis-Solidaginis* Arth., as field observations indicated that they belonged to a *Puccinia* on *Carex*.

Aecia were also collected on *Solidago latifolia* L., which differed from the more common aecia on *Solidago* being in very small groups or solitary and pale or whitish. They probably belong to a distinct species.

Peridermium.

All aecial forms inhabiting the *Pinaceae* and *Gnetaceae* and possessing peridia are usually included under this form genus. They are probably the aecial stages of rusts belonging to the families *Melampsoraceae* and *Cronartiaceae*. All *Peridermia* that have been connected with telial forms belong to these families except a few leaf inhabiting species on *Pinus* which belong to the genus *Coleosporium*.

I have collected ten species in the vicinity of Pictou. They are tablulated below and their connexions with telial genera where known:

Peridermium decolorans Peck.—*Melampsoropsis ledicola* (Peck) Arth.

Per. consimile Arth. & Kern.—*Mel. Cassandrae* (Peck & Clinton) Arth.

Per. abietinum (A. & S.) Thuem.—*Mel. abietina* (A. & S.) Arth.

Per. columnare (A. & S.) Kunze & Schm.—*Calyptospora columnaris* (A. & S.) Kuehn.

Per. elatinum (A. & S.) Kunze & Schm.—*Melampsorella elatina* (A. & S.) Arth.

Per. conorum-Piceae (Rees) Arth. & Kern.—*Melampsoropsis Pyrolae* (DC.) Arth.

Per. Peckii Thuem.—*Pucciniastrum minimum* (Schw.) Arth.

Peridermium (on *Tsuga*).—*Puccinistrum Myrtilli* (Schum.) Arth.

The connexion of the following form has not yet been established:

Per. balsameum Peck.

Two other species may occur in Nova Scotia, *Per. coloradense* (Diet.) Arth. & Kern, and *Per. Laricis* (Kleb.) Arth. & Kern. The former has been collected in Maine. It forms witches' brooms on *Picea* and is conspicuous. The latter has not been collected in North America, but as the telial form on *Betula* [*Melampsoridium Betulae* (Schum.) Arth.] is rather common, it will doubtless be found also.

Peridermium balsameum Peck.

0. Pycnia hypophyllous, few, scattered, honey-yellow, small.

I. Aecia hypophyllous, in two irregular rows on yellowish areas occupying all or part of the leaf, white, mostly cylindrical, small, opening at apex; peridium colourless, margin erose or somewhat lacerate. Aeciospores ellipsoid or globoid, 15-22 by 19-27μ, wall thin, densely verrucose; contents colourless.

On *Abies balsamea* (L.) Mill., Pictou, July 15, 1909; Scotsburn, August, 17, 1909; Folleigh Lake, August 31, 1919.

This species is characterized by its white spores, no other *Peridermium* in Eastern North America shows this character. It may be identical with the European *Aecidium pseudocolumnare* Kuhn, which also has white spores, (See note Arthur & Kern, Bull. Torr. Bot. Club 33:436. 1906).

From field study the writer is convinced that *Peridermium balsameum* is the aecial stage of some species of the genus *Uredinopsis*. Probably several species are confused under this *Peridermium*.

Caeoma.

Aecia without peridia of which the telial forms are not known are classed here. I have collected three of these forms in Nova Scotia, *Caeoma nitens* on the raspberry, the aecidial stage of *Gymnoconia interstitialis,* a *Caeoma* on *Abies balsamea,* which I have shown to be the aecial stage of *Melampsora arctica;* and *Caeoma Abietis-canadensis* Farl., which I have connected with *Melampsora Medusae.*

Roestelia.

The name *Roestelia* has been applied to the aecial stage of the *Gymnosporangium* rusts. The peridium is well developed and dehisces by longitudinal slits, and thus soon becomes fimbriate and revolute. The Nova Scotia collections are discussed under the genus *Gymnosporangium.*

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NOTE.

Since this paper was revised the writer by culture experiments during the early summer of 1912 established the life history of several of the fern rusts of the genus *Uredinopsis*. These experiments have shown that *Uredinopsis Osmundae* Magn., *U. Struthiopteridis* Stormer, *U. Phegopteridis* Arthur,

U. mirabilis (Peck) Arthur, and *U. Atkinsonii* Magn., have their aecial stages on *Abies balsamea* (L.) Mill. The aecia are the white spored forms that have passed as *Peridermium balsameum* Peck.

The question arises whether these are distinct species with like aecia or only one species that has been regarded as distinct on account of minor differences. The experiments as far as they went tended to show that the species established are good or at least are races of the same species.

The following European species has also been recognized since the paper was revised. It adds a new species to the American flora. The determination was made by Dr. J. C. Arthur.

Puccinia karelica Tranz.

0. I. Pycnia and aecia in *Trientalis americana* (Pers.) Pursh. Pictou, June 20, 1912.

II & III. Uredinia and telia in *Carex paupercula* Michx., Pictou, Folleigh Lake.

NOTE.

The following additional species were collected after the preceding paper was in type.

Hyalopsora.

Cycle of development not understood; telia and two other spore forms known, called aecia and uredinia; aecia and uredinia sub-epidermal, telia within the epidermal cells.

Hyalopsora Aspidiotus (Peck) Magn.

I. Aecia amphigenous, rounded, small, yellow, tardily dehiscent. Aeciospores ellipsoid or polyhedral, large, 30-40 by 40-50μ; wall thick 2.5-3.5μ, colorless, verrucose.

II. Uredinia amphigenous, irregularly scattered, round, small, golden-yellow, somewhat pulverulent; peridium delicate.

Urediniospores ellipsoid or oval, 19-24 by 29-35μ; wall colourless, medium thick, minutely verrucose.

III. Telispores in the epidermal cells, globoid, often irregular 25 by 21-35μ; usually four-celled; wall thin, 1μ, colorless, smooth.

On *Phegopteris Dryopteris* (L.) Fee., Pictou, New Glasgow, July, 1912.

The spores appeared so early in spring that it does not seem probable that they are preceded by aecia on another host, so the writer is inclined to regard this species as autoecious.

The description of the genus and species is based on that of Arthur in the *North American Flora* as all the spore forms were not present on my collections.

Puccinia Osmorrhizae (Peck) Cooke and Peck.

O. & I. Not present on Nova Scotia collections.

II. Uredinia amphigenous, scattered, rather small, pulverulent, cinnamon. Urediniospores mostly ovate, yellowish, about 25 by 28μ; wall echinulate, thick.

III. Telia blackish, elongate on the stem and pedicels. Teliospores ellipsoid, rounded at both ends, slightly constricted at the septum, 21-27 by 28-35μ; wall rather thin, slightly or not at all thickened at the apex, reticulate; pedicel delicate, hyaline, deciduous, shorter than the spore.

On *Osmorrhiza Claytoni* (Michx.) Clarke., New Glasgow, July, 1912.

OMISSION FROM PAGE 364.

The third paragraph from the bottom of the page has only the first and last line of the author's paragraph which should read as follows:

III. Telia hypophyllous, evenly and closely scattered, occupying all or part of the under surface of the leaf, small, round, .2-.45 mm. across, waxy, at first yellowish-red, afterward dull-red; Teliospores ellipsoid, 12-15 by 12-19μ; wall colorless smooth, thin; basidiopores 7-8μ in diameter.

Pycnia and aecia on the cones of *Picea mariana* (Mill.) BSP., *P. canadensis* (Mill.) BSP., Pictou, July, 1910, 1911.

Uredinia and telia on *Pyrola americana* Sweet, Pictou, Truro; *P. elliptica* Nutt., Pictou.

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Potentilla canadensis.
Phragmidium Potentillae-canadensis.

Prenanthes altissima.
Puccinia orbiculata.

Puccinellia maritima.
Puccinia cinerea.

Pyrola americana.
Melampsoropsis Pyrolae.

Pyrola elliptica.
Melampsoropsis Pyrolae.
Pucciniastrum Pyrolae.

Ranunculus acris.
Puccinia perplexans.

Ranunculus cymbalaria.
Puccinia cinerea.

Ranunculus maritima.
Puccinia cinerea.

Ranunculus repens.
Uromyces Poae.

Rhamnus cathartica.
Puccinia Lolii.

Rhodora canadense.
Pucciniastrum minimum.

Ribes oxyacanthoides.
Puccinia albiperidia.

Ribes prostratum.
Puccinia albiperidia.

Rosa sp.
Phragmidium americanum.
Phragmidium speciosum.

Rubus glandicaulis.
Gymnoconia interstitialis.

Rubus hispidus.
Kuehneola albida.

Rubus ideaus Var. aculeatissimus.
Phragmidium imitans.
Pucciniastrum arcticum.

Rubus triflorus.
Pucciniastrum arcticum.

Rumex Acetosella.
Puccinia Acetosae.

Salix discolor.
Melampsora arctica.

Salix rostrata.
Melampsora arctica.
Melampsora Bigelowii.

Sambucus canadensis.
Puccinia Sambuci.

Scirpus campestris Var. paludosus.
Uromyces Scirpi.

Scirpus cyperinus.
Puccinia angustata.

Scirpus rubrotinctus.
Puccinia angustata.

Scirpus validus.
Uromyces Scirpi.

Secale cereale.
Puccinia graminis.

Solidago bicolor.
Coleosporium Solidaginis.
Uromyces perigynius.

Solidago canadensis.
Coleosporium Solidaginis.
Aecidium compositorum var. Solidaginis.

Solidago graminifolia.
Puccinia Caricis-solidaginis.

Solidago nemoralis.
Puccinia Solidaginis.

Solidago puberula.
Puccinia Solidaginis.

Solidago rugosa.
Aecidium compositorum var. Solidaginis.
Coleosporium Solidaginis.

Spartina glabra Var. alterniflora.
Uromyces Spartinae.

Spartina Michauxiana.
Uromyces Spartinae.

Spartina patens.
Uromyces Spartinae.

Spergularia canadensis.
Uromyces Spartinae.

Taraxacum officinale.
Puccinia Taraxaci.
Puccinia variabilis.

Thalictrum polygonum Var. hebecarpum.
Puccinia Thalictri.

Trientalis americana.
Puccinia karelica.

Trifolium hybridum.
Uromyces Trifolii-repentis.

Trifolium pratense.
Uromyces Trifolii.

Tsuga canadensis.
Necium Farlowii.
Melampsora Medusae.
Pucciniastrum minimum.
Pucciniastrum Myrtilli.

Vaccinium pennsylvanicum.
Calyptospora columnaris.
Pucciniastrum Myrtilli.

Vicia Cracca.
Uromyces Fabae.

Viola cucullata.
Puccinia Violae.

Zea Mays.
Puccinia Maydis.

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THE OCCURRENCE OF OPAL IN GRANITE NEAR NEW ROSS, LUNENBURG COUNTY, N. S.—BY HARRY PIERS, Curator of the Provincial Museum, Halifax, N. S.

Read 23rd May, 1910.

On 15th March, 1910, the Provincial Museum received from Charles Keddy of Lake Ramsay, near New Ross, Lunenburg County, N. S., a prospector whose name is connected with the discovery in 1906 of tin ore and other minerals in that interesting district, a small mineral specimen which he desired to have identified (museum accession no. 3538).

He stated that he had found it in a vein of quartz, about two or three inches wide, cutting mixed red and white granite, on land owned by Amos Gates, between New Ross and Lake Ramsay, Lunenburg County, N. S. The location is 1⅝ mile west of the cross-roads at New Ross, and 1½ mile southeast of the south end of Lake Ramsay, while it is about ¼ of a mile south of the Dalhousie Road and about ⅜th of a mile east of Larder River. From the cassiterite deposit at John Reeves's, it is 1½ mile east, and about ¾ of a mile northeast of the molybdenite occurrence on Larder River. (Vide map of the district marked by Mr. Keddy).

It is presumed that this quartz-vein, is related to the pegmatite dikes and schlierens which are met with in that district, and in one of which occurs the cassiterite which has been reported on.* It is probable that the vein is the ultimate penetration of pegmatitic matter into the granite, as granitic dikes are frequently found to pass at length into quartz alone, the mica and orthoclase constituents having been earlier deposited, thus leaving the acidic remainder to intrude furthest into the enclosing mass.

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*Piers.—Occurrence of Tin in Nova Scotia: Trans. N. S. Inst. Science, xii, pt. 3, p. 239.

The specimen is the Girasol variety of Opal, which is defined by Dana as "bluish-white, translucent, with reddish reflections in a bright light." More play of colours or fire-like reflections would make it a Precious or a Fire-opal; and a lack of such colour, a Common Opal.

The specimen furnishes the following description: Its greatest length is .35 of an inch; and its thickness about .22 of an inch. The original weight was 40.9 centigrammes. Hardness about 6. Specific gravity, 2.12 (Opal has a specific gravity varying from 1.9 to 2.3; but when pure, from 2.1 to 2.2; being thus less than quartz, which is from 2.5 to 2.8). The lustre is vitreous or subvitreous. Colour milk-white, with rather feeble internal reflections or glows of a delicate vinaceous-pink (pale yellowish pink) colour, when turned about in a strong light. Streak white. In diaphaneity it is subtransparent.

It is soluble, when powdered, in strong, hot potassium hydroxide; gives off water when heated in the closed tube; is infusible before the blowpipe; and is readily scratched by quartz (7) and scratches apatite (5). These characteristics and its low specific gravity plainly show that it is not any of the varieties of ordinary quartz.

Mr. Keddy writes me (18th May, 1910) that he has a smaller specimen which is much handsomer, having more play of colours, red, yellow and blue; and if this is so, it must more nearly approach the Precious Opal.

With these handsomer specimens, he says, there were found others, reddish-brown and yellow, and opaque; all occurring in the same quartz vein. The Museum received from him on 19th November, 1910, two of these latter duller specimens (accession no. 3661). They consist of Common Opal (milky white) in what is doubtless Jasp-opal (brownish yellow). One of these two specimens weighs 21.1 centigrammes and is of a cinnamon (brownish yellow) colour and opaque; with milk-

white, opaque, to greyish translucent patches and minute mottlings and spots; and it has a specific gravity in the whole of 2.24. The other one, which weighs 24.7 centigrammes, is mostly of a cinnamon colour, dull and opaque; with minute circular spots of milk-white, opaque mineral; and has a specific gravity of 2.34. The higher specific gravity of these two specimens as compared with the Girasol, is doubtless owing to the impure brownish yellow mineral in the former, whose colour is owing to the presence of impurity in the form of iron oxide.*

The occurrence of Opal near New Ross is a very interesting addition to the long list of rare or otherwise noteworthy minerals found in that locality.† The Opals here described are not brilliant enough to make them of commercial value as precious stones, but it is not unlikely that others of finer fire may yet be found there.

Regarding the finding of Opal in Nova Scotia in the past, it may be noted that Dr. Abraham Gesner ("Geology and Mineralogy of N. S.," 1836, p. 248) speaks of the occurrence of Opal and Semiopal in the triassic trap of Partridge Island, Cumberland County, N. S., and says he had obtained two small nodules of the former, both resembling pieces of wax. Prof. Henry How ("Mineralogy of N. S.," 1869, p. 185) refers to Gesner's statement just mentioned, and says that Semiopal or Common Opal is found at a few localities in the

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*Another specimen received on 18th April, 1913, from Mr. Keddy is about an inch in diameter, and was thought by him to be Common Opal, but on examination proves to be Chalcedony. It is cryptocrystalline, has a concoidal fracture, scratches glass readily (hardness 7), is subtranslucent, has a dull waxy lustre, and is white in color. It has a specific gravity of 2.56 (which is greater than that of Opal), and is not soluble in hot potassium hydroxide. Small tongues of greyish translucent mineral penetrate a short distance from the sides, and may possibly be opal-silica, which would account for the specific gravity being slightly below the normal for Chalcedony (2.60-2.64). The lack of sharp edges to this specimen, at first suggested that it might have been found loose in the soil, but Mr. Keddy assures me that he got it out of the Opal-bearing vein when he was taking off its surface.

†See Trans. N. S. Inst. Science, xii, p. 3, p. 246. Also Faribault (E. R.), Summary Report Geol. Survey Canada, 1907, p. 80; and Young (G. A.), ib. p. 77.

province, that it is generally white or nearly so in colour, and that some of the mineral so called may be Cacholong. A specimen which he considered to be Opal-agate was found as a loose pebble at Beech Hill, to the southward of Kentville, Kings County, and a portion of it was sent to Mr. Julius Cornelius, jeweller, of Halifax, who had it cut and polished, and so produced handsome seal or ring-stones composed of white and bluish-white stripes about the sixteenth of an inch thick. The only occurrences mentioned in How's list of mineral localities are at "Partridge Island (opal, semiopal)," and "Beech Hill (opal-agate, loose)." Diatomaceous Earth, which chemically is a variety of Opal, is found in a large number of lakes of Nova Scotia; and Cacholong is also a variety of the same mineral. These, however, are of no interest to the lapidary.

Precious and Common Opal usually occur as hydration products filling cavities and fissures or seams in igneous rocks, such as trachyte, porphyry, etc.; also in mineral veins and elsewhere.

In closing, it may be mentioned that a beautiful blue, transparent mineral is reported to have been found by John Reeves in in the pegmatite debris at the tin prospect on his land about ⅞ of a mile south-southwest of the south extremity of Lake Ramsay, to the west of New Ross. It was shown to me, and is undoubtedly very beautiful, but I had no opportunity of making an examination whereby its character might be ascertained. It has been suggested that it may be a blue Beryl, which is not improbable. Beryls have been found there, although I presume that they were of the common green variety.

APPENDIX I.

LIST OF MEMBERS, 1906-07.

ORDINARY MEMBERS.

	Date of Admission.
Bayer, Rufus, Halifax	March 4, 1890
Bishop, Watson L., Supt. of Water Works, Dartmouth, N. S.	Jan. 6, 1890
Bowman, Maynard, B. A., Public Analyst, Halifax	March 13, 1884
Brown, Richard H., Halifax	Feb. 2, 1903
Budge, Daniel, General Supt. Halifax & Bermuda Cable Co., Halifax	Oct. 30, 1903
*Campbell, Donald A., M. D., Halifax	Jan. 31, 1890
Campbell, George Murray, M. D., Halifax	Nov. 10, 1884
Colpitt, Parker R., City Electrician, Halifax	Feb. 2, 1903
*Davis, Charles Henry, C. E., New York City, U. S. A	Dec. 5, 1900
Dixon, Prof. Stephen Mitchell, B. A., B. A. I., University of Birmingham, Birmingham, England	April 8, 1902
Doane, Francis William Whitney, City Engineer, Halifax	Nov. 3, 1886
Donkin, Hiram, C. E., Deputy Com. of Mines, Halifax	Nov. 30. 1892
Egan, Thomas J., Halifax	Jan. 6. 1890
Fearon, James, Principal, Deaf and Dumb Institution, Halifax	May 8, 1894
*Forbes, John, Moncton, N. B.	March 14. 1883
*Fraser, C. Frederick, LL. D., Principal, School for the Blind, Halifax	March 31 1890
Freeman, Philip A., engineer, Hx. Elec. Tramway Co., Hx.	Nov. 6, 1906
Gates, Herbert E., Architect, Halifax	April 17, 1899
Hattie, William Harrop, M. D., Supt. N. S. Hospital, Dartmouth	Nov. 12, 1892
Hayward, A. A., Halifax	Nov. 7, 1905
Irving, G. W. T., Education Dept., Halifax	Jan. 4, 1892
Jack, Prof. Ernest Brydone, M. A., C. E.. Dalhousie College, Halifax	Nov. 7, 1905
Johnston, Harry W., C. E., Asst. City Engineer, Halifax	Dec 31, 1894
*Laing, Rev. Robert, Halifax	Jan. 11, 1885
McCarthy, Prof. J. B., B. A., M. SC., King's College, Windsor, N. S	Dec. 4, 1901
McColl, Roderick, C. E., Provl. Engineer, Halifax	Jan. 4, 1892
Macdonald, Simon D., F. G. S., Halifax	March 14, 1881
*MacGregor Prof. James Gordon, M. A., D. SC., F. R. S., F. R. S. C., Edinburgh University, Edinburgh, Scotland	Jan. 11, 1877
McInnes, Hector, LL. B., Halifax	Nov. 27, 1889
*McKay, Alexander, Supervisor of Schools, Halifax	Feb. 5, 1872
*MacKay, Alexander Hector, B. A., B. SC., LL. D., F. R. S. C., Superintendent of Education, Halifax	Oct.. 11, 1885
MacKay, Prof. Ebenezer, PH. D., Dalhousie College, Halifax	Nov. 27, 1889
*MacKay, George M. Johnstone, Dartmouth, N. S	Dec. 18, 1903
MacKenzie, Prof. Arthur Stanley, PH. D., Dalhousie College, Halifax	Nov. 7, 1905
McKerron William, Halifax	Nov. 30, 1891

*Life Members.

Date of Admission.

Marshall, Gilford R., Principal, Compton Avenue School, Halifax .... April 4, 1894
Morton, S. A., M. A., County Academy, Halifax .... Jan. 27, 1893
Murphy, Martin, C. E., D. SC., I. S. O., Saskatoon, Sask .... Jan. 15, 1870
Murray, Prof. Daniel Alexander, Ph. D., Dalhousie College, Halifax .... Dec. 18, 1903
Piers, Harry, Curator Provincial Museum and Librarian Provincial Science Library, Halifax .... Nov. 2, 1888
*Poole, Henry Skeffington, A. M., ASSOC. R. S. M., F. G. S., F. R. S. C., M. CAN. SOC. C. E., HON. MEM. INST. M. E., Halifax .... Nov. 11, 1872
Read, Herbert H., M. D., L. R. C. S., Halifax .... Nov. 27, 1889
*Robb, D. W., Amherst, N. S .... March 4, 1890
Rutherford, John, M. E., Halifax .... Jan. 8, 1865
Sexton, Prof. Frederic H., Director of Technical Education, Halifax..... Dec. 18, 1903
*Smith, Prof. H. W., B. SC., Agricultural School, Truro, N. S.; Assoc. Memb., Jan. 6, 1890 .... Dec. 1900
*Stewart, John, M. B. C. M., Halifax .... Jan. 12, 1885
Wheaton, L. H., Chief Engineer, Coast Railway Co., Yarmouth, N. S.... Nov. 29, 1894
Wilson, Robert J., Secretary, School Board, Halifax .... May 3, 1889
Winfield, James H., Manager, N. S. Telephone Co., Halifax........ Dec. 18, 1903
Woodman, Prof J. Edmund, M. A., D. SC., School of Mining and Metallurgy, Dalhousie College, Halifax .... Dec. 3, 1902
*Yorston, W. G., C.E., City Engineer, Sydney, C. B .... Nov. 12, 1892

ASSOCIATE MEMBERS.

Archibald, Monro, B. A., B. SC., Truro, N. S. .... Nov. 7, 1905
*Caie, Robert, Yarmouth, N. S .... Jan. 31, 1890
*Dickenson, S. S., Commercial Cable Co., New York, U. S. A........ March 4, 1895
Edwards, Arthur M., M. D., F. L. S., Newark, N. J .... Dec. 12, 1898
Gates, Reginald R., University of Chicago, Chicago, Ill., U. S. A. .... Feb. 2, 1903
Haley, Prof. Frank R., Acadia College, Wolfville, N. S .... Nov. 5, 1901
Harlow, L. C., B. SC., Prov. Normal School, Truro, N. S .... March 23, 1905
Haycock, Prof. Ernest, Acadia College, Wolfville, N. S .... May 17, 1899
Hunton, Prof. S. W., M. A. Mount Allison College, Sackville, N. B .... Jan. 6, 1890
Jaggar, Miss A Louise, Cambridge, Mass .... Dec. 5, 1900
James, C. C., M. A., Depy. Min. of Agriculture, Toronto, Ontario .... Dec. 3, 1896
Jennison, W. F., Sydney, C. B .... May 5, 1903
*Johns, Thomas W., Yarmouth, N. S .... Nov. 27, 1889
*Keating, E. H., C. E., Toronto Ry. Co., Toronto Ont.; Ord. Memb. April 12, 1882 .... April 11, 1900
Lawrence, H., D. D. S., Wolfville, N. S .... March 9, 1903
McIntosh, Kenneth, St. Peters, C. B.; Ord. Memb., Jan. 4, 1892........ June 1900
*MacKay, Hector H., M. D., New Glasgow, N. S .... Feb. 4, 1902
McKenzie, W. B., C. E., Moncton, N. B .... March 31, 1882
McLeod, R. R., Brookfield, N. S .... Dec. 3, 1897
Magee, W. H., PH. D., Annapolis, N. S .... Nov. 29, 1894
Matheson, W. G., New Glasgow, N. S .... Jan. 31, 1890
Payzant, E. N., M. D., Wolfville, N. S .... April 8, 1902
Pineo, Avard V., LL. B., Kentville, N. S .... Nov. 5, 1901
*Reid, A. P., M. D., L. R. C. S., Middleton, Annapolis Co., N. S........ Jan. 31, 1890
*Robinson, C. B., B.A., New York Botanical Garden, New York, U. S. A.. Dec. 3, 1902
*Rosborough, Rev. James, Musquodoboit Harbour, N. S........ Nov. 29, 1894
Russell, Prof. Lee, B. S., Worcester, Mass........ Dec. 3, 1896
Sawyer, Prof. Everett W., Acadia College, Wolfville, N. S........ Feb. 6, 1901

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*Life Members.

CORRESPONDING MEMBERS.

Ami, Henry M., D. SC., F. G. S., F R. S. C., Geological Survey, Ottawa, Ontario.. Jan. 2, 1892
Bailey, Prof. L. W., PH. D., LL. D., F. R. S. C., Fredericton, N. B..........Jan. 6, 1890
Ball, Rev. E. H., Tangier, N. S..Nov. 29, 1871
Bethune, Rev. Charles J. S., M. A., D. C. L, F. R. S. C, Ontario Agricultural College, Guelph, Ont..Dec. 29, 1868
Cox, Philip, B. SC., PH. D., Chatham, N. B...................................Dec. 3, 1902
Dobie, W. Henry, M. D., Chester, England ....Dec. 3, 1897
Ells, R. W., LL. D., F. G. S. A., F. R. S. C., Geological Survey, Ottawa, Ont . Jan. 2, 1894
Faribault, E. Rodolphe, B. A., B. SC., Geological Survey of Canada, Ottawa ; Assoc. Memb., March 6, 1888 ....Dec. 3, 1902
Fletcher, Hugh, B. A., Geological Survey, Ottawa, Ontario ....March 3, 1891
Fletcher, James, LL. D., F. L. S, F. R. S. C., Entomologist and Botanist, Central Exp. Farm, Ottawa, Ontario ....March 2, 1897
Ganong, Prof. W. F., B. A., PH. D., Smith College, Northampton, Mass., U. S. A ....Jan. 6, 1890
Hardy, Maj -General Campbell, R. A., Dover, England. (Originally admitted Jan. 26, 1863)...Oct. 30, 1903
Harrington, W. Hague, F. R. S. C., Post Office Department, Ottawa ......May 5, 1896
Hay, George U., D. SC, F. R. S C., St. John, N. B.............................Dec. 3, 1902
Litton, Robert T., F. G. S., Melbourne, Australia...........................May 5, 1892
McSwain, John, Charlottetown, P. E. I.......................................Dec. 3, 1902
Matthew, G. F., M. A., D. SC., F. R. S. C., St. John, N. B ....Jan. 6, 1890
Maury, Rev. Mytton, D. D., Ithaca, N. Y., U. S. A.............................Nov. 30, 1891
Mowbray, Louis L., Hamilton, Bermuda..May 3, 1907
Peter, Rev. Brother Junian, Fall River, Mass., U. S. A .... Dec. 12, 1898
Pickford, Charles, Halifax...March 2, 1900
Prest, Walter Henry, M. E, Webbwood, Ont; Assoc. Memb., Nov. 29. 1894, Nov. 2, 1900
Prichard, Arthur H. Cooper...Dec. 4, 1901
Prince, Prof. E. E., Commissioner and General Inspector of Fisheries, Ottawa, Ontario ....Jan. 5, 1897

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* Life Members.

LIST OF PRESIDENTS

OF THE NOVA SCOTIAN INSTITUTE OF NATURAL SCIENCE, AFTERWARDS THE NOVA SCOTIAN INSTITUTE OF SCIENCE, SINCE ITS FOUNDATION IN 1862.

	Term of Office.		
Hon. Philip Carteret Hill, D. C. L.	31 Dec. 1862	to	26 Oct. 1863
John Matthew Jones, F. L. S., F. R. S. C.	26 Oct. 1863	"	8 Oct. 1873
John Bernard Gilpin, M. A., M. D., M. R. C. S.	8 Oct. 1873	"	9 Oct. 1878
William Gossip	9 Oct. 1878	"	13 Oct. 1880
John Somers, M. D.	13 Oct. 1880	"	26 Oct. 1883
Robert Morrow	26 Oct. 1883	"	21 Oct. 1885
John Somers, M. D.	21 Oct. 1885	"	10 Oct. 1888
Prof. James Gordon MacGregor, M. A., D. SC., F.R.S.. F.R.S.C.	10 Oct. 1888	"	9 Nov. 1891
Martin Murphy, C. E., D. SC., I. S. O.	9 Nov. 1891	"	8 Nov. 1893
Prof. George Lawson, PH. D., LL. D., F. I. C., F. R. S. C.	8 Nov. 1893	"	10 Nov. 1895
Edwin Gilpin, Jr., M. A., LL. D., D. SC., F. G. S., F. R. S. C., I.S.O.	18 Nov. 1895	"	8 Nov. 1897
Alexander McKay	8 Nov. 1897	"	20 Nov. 1899
Alexander Howard MacKay, B. A., B. SC., LL. D., F. R. S. C.	20 Nov. 1899	"	24 Nov. 1902
Henry Skeffington Poole, M. A., D. SC., A. R. S. M., F. G. S., F. R. S. C.	24 Nov. 1902	"	18 Oct. 1905
Francis William Whitney Doane, C. E.	18 Oct. 1905	"	11 Nov. 1907
Prof. Ebenezer MacKay, PH. D.	11 Nov. 1907	"	———

NOTE—Since 1879 the presidents of the Institute have been *ex-officio* Fellows of the Royal Microscopical Society.

The first general meeting of the Nova Scotian Institute of Natural Science was held at Halifax, on 31st December, 1862. On 24th March, 1890, the name of the society was changed to the Nova Scotian Institute of Science, and it was incorporated by an act of the legislature in the same year.

V

APPENDIX II.

LIST OF MEMBERS, 1907-08.

ORDINARY MEMBERS.

Name	Date of Admission
Bancroft, George R., Hx. Academy, Halifax	Jan. 7, 1908
Bayer, Rufus, Halifax	March 4, 1890
Bishop, Watson L., Supt. of Water Works, Dartmouth, N. S.	Jan. 6, 1890
Bowman, Maynard, B. A., Public Analyst, Halifax	March 13, 1884
Brown, Richard H., Halifax	Feb. 2, 1903
Budge, Daniel, General Supt. Halifax & Bermuda Cable Co., Halifax	Oct. 30, 1903
*Campbell, Donald A., M. D., Halifax	Jan. 31, 1890
Campbell, George Murray, M. D., Halifax	Nov. 10, 1884
Colpitt, Parker R., City Electrician, Halifax	Feb. 2, 1903
Creighton, H. Jermain M., M. A., Dartmouth	Jan. 7, 1908
*Davis, Charles Henry, C. E., New York City, U. S. A	Dec. 5, 1900
Dixon, Prof. Stephen Mitchell, B. A., B. A. I., University of Birmingham, Birmingham, England	April 8, 1902
Doane, Francis William Whitney, City Engineer, Halifax	Nov. 3, 1886
Donkin, Hiram, C. E., Deputy Com. of Mines, Halifax	Nov. 30. 1892
Egan, Thomas J., Halifax	Jan. 6, 1890
Fearon, James, Principal, Deaf and Dumb Institution, Halifax	May 8, 1894
*Forbes, John, Halifax	March 14, 1883
*Fraser, C. Frederick, LL. D., Principal, School for the Blind, Halifax	March 31, 1890
Freeman, Philip A., engineer, Hx. Elec. Tramway Co., Hx.	Nov. 6, 1906
Gates, Herbert E., architect, Halifax	April 17, 1899
Harlow, A. C., Morris St. School, Halifax	Jan. 7, 1908
Hattie, William Harrop, M. D., Supt. N. S. Hospital, Dartmouth	Nov. 12, 1892
Hayward, A. A., Halifax	Nov. 7, 1905
Irving, G. W. T., Education Dept., Halifax	Jan. 4, 1892
Johnston, Harry W., C. E., Asst. City Engineer, Halifax	Dec. 31, 1894
*Laing, Rev. Robert, Halifax	Jan. 11, 1885
McCallam, A. L., B. SC., analyst, Halifax	Jan. 7, 1908
McCarthy, Prof. J. B., B. A., M. SC., King's College, Windsor, N. S	Dec. 4, 1901
McColl, Roderick, C. E., Provl. Engineer, Halifax	Jan. 4, 1892
*MacGregor, Prof. James Gordon, M. A., D. SC., F. R. S., F. R. S. C., Edinburgh University, Edinburgh, Scotland	Jan. 11, 1877
McInnes, Hector, LL. B., Halifax	Nov. 27, 1889
*McKay, Alexander, Supervisor of Schools, Halifax	Feb. 5, 1872
*MacKay, Alexander Hector, B. A., B. SC., LL. D., F. R. S. C., Superintendent of Education, Halifax	Oct. 11, 1885
MacKay, Prof. Ebenezer, PH. D., Dalhousie College, Halifax	Nov. 27, 1889
*MacKay, George M. Johnstone, Dartmouth, N. S	Dec. 18, 1903
MacKenzie, Prof. Arthur Stanley, PH. D., Dalhousie College, Halifax	Nov. 7, 1905
McKerron, William, Halifax	Nov. 30, 1891
Macneill, Prof. Murray, Dalhousie College	Jan. 7, 1908

*Life Members.

Date of Admission.

Marshall, Guilford R., B. A., Halifax......April 4, 1894
Moore, Clarence L., M. A., Superv. of Schools, Sydney......Jan. 7, 1908
Morton, S. A., M. A., County Academy, Halifax......Jan. 27, 1893
Murphy, Martin, C. E., D. SC., I. I. O., Saskatoon, Sask......Jan. 15, 1870
Murray, Prof. Daniel Alexander, Ph. D., Montreal......Dec. 18, 1903
Pickings, H. B., Mines Department. Halifax......May 6, 1908
Piers, Harry, Curator Provincial Museum and Librarian Provincial Science Library, Halifax......Nov. 2, 1888
*Poole, Henry Skeffington, A. M., ASSOC. R. S. M., F. G. S., F. R. S. C., M. CAN. SOC. C. E., HON. MEM. INST. M. E., Devonport. England......Nov. 11, 1872
Read, Herbert H., M. D., L. R. C. S., Halifax......Nov. 27, 1889
*Robb, D. W., Amherst, N. S......March 4, 1890
Robinson, Ernest, B. A., Dartmouth, N. S......Jan. 7, 1908
Rutherford, John, M. E., Halifax......Jan. 8, 1865
Sexton, Prof. Frederic, H., Director of Technical Education, Halifax....Dec 18, 1903
*Smith, Prof. H. W., B. SC., Agricultural School, Truro, N. S; Assoc. Memb. Jan. 6. 1890......Dec. 1900
*Stewart, John, M. B. C. M., Halifax......Jan. 12, 1885
Stone, Prof. A. E., Dalhousie College, Halifax......Jan. 7, 1908
Wheaton, L. H., Chief Engineer, Coast Railway Co., Yarmouth, N S....Nov. 29, 1894
Wilson, Robert J., Secretary, School Board, Halifax......May 3, 1889
Winfield, James H., Manager, N. S. Telephone Co., Halifax......Dec. 18, 1903
Woodman, Prof. J. Edmund, M. A. D. SC., School of Mining and Metallurgy, Dalhousie College, Halifax......Dec. 3, 1902
*Yorston. W. G., C. E., City Engineer, Sydney, C. B......Nov. 12, 1892

ASSOCIATE MEMBERS.

Archibald, Monro, B. A., B. SC., Truro, N. S......Nov. 7, 1905
*Caie, Robert, Yarmouth, N. S......Jan. 31, 1890
*Dickenson, S. S., Commercial Cable Co, New York, U. S. A......March 4, 1895
Edwards, Arthur M., M. D., F. L. S., Newark, N. J...... Dec. 12, 1898
Gates, Reginald R. University of Chicago. Chicgao, Ill., U. S. A ......Feb. 2, 1903
Haley, Prof. Frank R., Acadia College, Wolfville, N. S......Nov. 5, 1901
Harlow, L. C., B. SC., Prov. Normal School, Truro, N. S......March 23, 1905
Haycock. Prof. Ernest, Acadia College, Wolfville, N. S......May 17, 1899
Hunton Prof. S. W., M. A., Mount Allison College, Sackville, N. B......Jan. 6, 1890
Jaggar, Miss A. Louise, Cambridge, Mass ...... Dec. 5, 1900
James, C. C., M. A., Deputy Min. of Agriculture, Toronto, Ontario......Dec. 3, 1896
Jennison, W. F. Sydney, C. B......May, 5, 1903
*Johns, Thomas W., Yarmouth, N. S. ......Nov. 27, 1889
*Keating, E. H., C. E., Toronto, Ont.; Order Memb. April, 12, 1882......April 11, 1900
Lawrence, H., D. D. S., Wolfville, N. S ......March 9, 1903
*MacKay, Hector, H., M. D., New Glasgow, N. S......Feb. 4, 1902
MacKenzie. W. B., C. E., Moncton, N. B ......March 31, 1882
Magee, W. H., PH. D., Annapolis, N. S......Nov. 29. 1894
Matheson, W. G., New Glasgow, N. S......Jan. 31, 1890
Payzant, E. N., M. D., Wolfville, N, S...... April 8, 1902
Pineo, Avard V., LL. B., Kentville, N. S......Nov. 5, 1901
*Reid, A. P., M. D., L. R. C. S., Middleton, Annapolis, N. S......Jan. 31, 1890
*Robinson, C. B., PH.D, New York Botanical Garden, New York, U.S.A.Dec. 3, 1902
*Rosborough, Rev. James, Musquodoboit Harbour, N. S......Nov. 29, 1894
Sawyer, Prof. Everett, W., Acadia College, Wolfville, N. S......Feb. 6, 1901

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*Life Members.

CORRESPONDING MEMBERS.

Ami, Henry M., D. SC., F. G. S., F R. S. C., Geological Survey, Ottawa, Ontario .... Jan. 2, 1892
Bailey, Prof. L. W., PH. D., LL. D., F. R. S. C., Fredericton, N. B .... Jan. 6, 1890
Ball, Rev. E. H., Tangier, N. S. .... Nov. 29, 1871
Bethune, Rev. Charles J. S., M. A., D. C. L., F. R. S. C., Ontario Agricultural College, Guelph, Ont. .... Dec. 29, 1868
Cox, Philip, B. SC., PH. D., Fredericton, N. B .... Dec. 3, 1902
Dobie, W. Henry, M. D., Chester, England .... Dec. 3, 1897
Ells, R. W., LL. D., F. G. S. A., F. R. S. C., Geological Survey, Ottawa, Ont .. Jan. 2, 1894
Faribault, E. Rodolphe, B. A., B. SC., Geological Survey of Canada, Ottawa ; Assoc. Memb., March 6, 1888 .... Dec. 3, 1902
Fletcher, Hugh, B. A., Geological Survey, Ottawa, Ontario .... March 3, 1891
Ganong, Prof. W. F., B. A., PH. D., Smith College, Northampton, Mass., U. S. A .... Jan. 6, 1890
Hardy, Maj.-General Campbell, R. A., Dover, England. (Originally admitted Jan. 26, 1863) .... Oct. 30, 1903
Harrington, W. Hague, F. R. S. C., Post Office Department, Ottawa ...... May 5, 1896
Hay, George U., D. SC, F. R. S C., St. John, N. B .... Dec. 3, 1902
Litton, Robert T., F. G. S., Melbourne, Australia .... May 5, 1892
Matthew, G. F., M. A., D. SC., F. R. S. C., St. John, N. B .... Jan. 6, 1890
Maury, Rev. Mytton, D. D., Ithaca, N. Y., U. S. A .... Nov. 30, 1891
Mowbray, Louis L., Hamilton, Bermuda .... May 3, 1907
Peter, Rev. Brother Junian .... Dec. 12, 1898
Prest, Walter Henry, M. E., Webbwood, Ont ; Assoc. Memb., Nov. 29, 1894, Nov. 2, 1900
Prichard, Arthur H. Cooper .... Dec. 4, 1901
Prince, Prof. E. E., Commissioner and General Inspector of Fisheries, Ottawa, Ontario .... Jan. 5, 1897
Whiteaves, J. F., LL. D., F. G. S., F. R. S. C., Govt. Suryey of Canada, Ottawa .... Nov. 4, 1907

LIST OF PRESIDENTS

OF THE NOVA SCOTIAN INSTITUTE OF NATURAL SCIENCE, AFTERWARDS THE NOVA SCOTIAN INSTITUTE OF SCIENCE, SINCE ITS FOUNDATION IN 1862.

	Term of Office.		
Hon. Philip Carteret Hill, D. C. L.	31 Dec. 1862	to	26 Oct. 1863
John Matthew Jones, F. L. S., F. R. S. C.	26 Oct. 1863	"	8 Oct. 1873
John Bernard Gilpin, M. A., M. D., M. R. C. S.	8 Oct. 1873	"	9 Oct. 1878
William Gossip	9 Oct. 1878	"	13 Oct. 1880
John Somers, M. D.	13 Oct. 1880	"	26 Oct. 1883
Robert Morrow	26 Oct. 1883	"	21 Oct. 1885
John Somers, M. D.	21 Oct. 1885	"	10 Oct. 1888
Prof. James Gordon MacGregor, M. A., D. SC., F.R.S.. F.R.S C.	10 Oct. 1888	"	9 Nov. 1891
Martin Murphy, C. E., D. SC., I. S. O.	9 Nov. 1891	"	8 Nov. 1895
Prof. George Lawson, PH. D., LL. D., F. I. C., F. R. S. C.	8 Nov. 1893	"	10 Nov. 1897
Edwin Gilpin, Jr., M. A., LL. D., D. SC., F. G. S., F. R. S. C., I.S.O.	18 Nov. 1895	"	8 Nov. 1899
Alexander McKay	8 Nov. 1897	"	20 Nov. 1893
Alexander Howard MacKay, B. A., B. SC., LL. D., F. R. S. C.	20 Nov. 1899	"	24 Nov. 1902
Henry Skeffington Poole, M. A., D. SC., A. R. S. M., F. G. S., F. R. S. C.	24 Nov. 1902	"	18 Oct. 1905
Francis William Whitney Doane, C. E.	18 Oct. 1905	"	11 Nov. 1907
Prof. Ebenezer MacKay, PH. D.	11 Nov. 1907	"	———

NOTE—Since 1879 the presidents of the Institute have been *ex-officio* Fellows of the Royal Microscopical Society.

The first general meeting of the Nova Scotian Institute of Natural Science was held at Halifax, on 31st December, 1862. On 24th March, 1890, the name of the society was changed to the Nova Scotian Institute of Science, and it was incorporated by an act of the legislature in the same year.

APPENDIX III.

LIST OF MEMBERS, 1908-09.

ORDINARY MEMBERS.

	Date of Admission
Bancroft, George R., Academy, Halifax	Jan. 7, 1908
Bishop, Watson L., Supt. Water Works, Dartmouth, N. S.	Jan. 6, 1890
Bowman, Maynard, B. A., Public Analyst, Halifax	Mar. 13, 1884
Brown, Richard H., Halifax	Feb. 2, 1903
Budge, Daniel, General Supt. Halifax & Bermuda Cable Co., Halifax	Oct. 30, 1903
*Campbell, Donald A., M. D., Halifax	Jan. 31, 1890
Campbell, George Murray, M. D., Halifax	Nov. 10, 1884
Colpitt, Parker R., City Electrician, Halifax	Feb. 2, 1903
Creighton H. Jermain M., M. A., D. SC., Dartmouth	Jan. 7, 1908
*Davis, Charles Henry, C. E., New York City, U. S. A.	Dec. 5, 1900
Doane, Francis William Whitney, City Engineer, Halifax	Nov. 3, 1886
Donkin, Hiram, M. E., Deputy Com. of Mines, Halifax	Nov. 30, 1892
Fergusson, Donald M., chemist, Acadia Sugar Ref. Co., Halifax	Jan. 5, 1909
*Forbes, John, Halifax	Mar. 14, 1883
*Fraser, C. Frederick, LL. D., Principal, School for the Blind, Halifax	Mar. 31, 1890
Freeman, Philip A., Hx. Elect. Tramway Co., Halifax	Nov. 6, 1906
Harlow, A. C., Morris Street School, Halifax	Jan. 7, 1908
Hattie, William Harrop, M. D., Supt. N. S. Hospital, Dartmouth	Nov. 12, 1892
Hayward, A. A., Halifax	Nov. 7, 1905
Irving, G. W. T., Education Dept., Halifax	Jan. 4, 1892
Johnston, Harry W., C. E., Asst. City Engineer, Halifax	Dec. 31, 1894
*Laing, Rev. Robert, Halifax	Jan. 11, 1885
McCallum, A. L., B. SC., analyst, Halifax	Jan. 7, 1908
McCarthy, Prof. J. B., B. A., M. SC., King's College, Windsor, N. S.	Dec. 4, 1901
McColl, Roderick, C. E., Provincial Engineer, Halifax	Jan. 4, 1892
*MacGregor, Prof. James Gordon, M. A., D. SC., F. R. S., F. R. S. C. Edinburgh University, Edinburgh, Scotland	Jan. 11, 1877
McInnes, Hector, LL. B., Halifax	Nov. 27, 1889
*McKay, Alexander, M. A., Supervisor of Schools, Halifax	Feb. 5, 1872
*MacKay, Alexander Hector, B. A., B. SC., LL. D., F. R. S. C., Superintendent of Education, Halifax	Oct. 11, 1885
Mackay, Prof. Ebenezer, PH. D., Dalhousie College, Halifax	Nov. 27, 1889
*MacKay, George M. Johnstone, Dartmouth, N. S.	Dec. 18, 1903
MacKenzie, Prof. Arthur Stanley, PH. D., Dalhousie College, Halifax	Nov. 7, 1905
McKerron, William, Halifax	Nov. 30, 1891
McLearn, F. H., B. A., Halifax	Oct. 14, 1908
Macneill, Prof. Murray, Dalhousie College	Jan. 7, 1908

*Life Members.

Date of Admission

Marshall, Guilford R., B. A., Halifax .... Apr. 4, 1894
Moore, Prof. Clarence L., M. A., Dalhousie College, Halifax .... Jan. 7, 1908
Morton, S. A., M. A., County Academy, Halifax .... Jan. 27, 1893
Murray, Prof. Daniel Alexander, PH. D., Montreal .... Dec. 18, 1903
Pickings, H. B., Mines Department, Halifax .... May 6, 1908
Piers, Harry, Curator Provincial Museum and Librarian Provincial
Science Library, Halifax .... Nov. 2 1888
*Poole, Henry Skeffington, A. M. ASSOC. R. S. M., F. G. S., F. R. S. C.
CAN. SOC. C. E., HON MEM. INST. M. E., Guildford, Surrey,
England .... Nov. 11, 1872
*Robb, D. W., Amherst, N. S. .... Mar. 4, 1890
Robinson, Ernest B. A., Canning, N. S. .... Jan. 7, 1908
Rutherford, John, M. E., Halifax .... Jan. 8, 1865
Sexton, Prof. Frederic H., Director of Technical Education, Halifax.. Dec. 18, 1903
*Smith, Prof. H. W. B. SC., Agricultural College, Truro, N. S.;
Assoc. Memb., Jan. 6, 1890 .... Dec. 1900
Stapleton, W. C., B. A., Supervisor of Schools, Dartmouth, N. S. .... Oct. 14, 1908
*Stewart, John, M. B. C. M., Halifax .... Jan. 12, 1885
Wilson, Robert J., Secretary, School Board, Halifax .... May 3 1889
Winfield, James H., Manager, N. S. Telephone Co., Halifax .... Dec. 18, 1903
Woodman, Prof. J. Edmund, M. A., D. SC., New York University,
New York, U. S. A. .... Dec. 3, 1902
*Yorston, W. G., C. E., City Engineer, Sydney, C. B. .... Nov. 12, 1892

ASSOCIATE MEMBERS.

Brodie, W. S., B. A., Lunenburg, N. S. .... May 7, 1909
*Caie, Robert, Yarmouth, N. S. .... Jan. 31, 1890
*Dickenson, S. S., Commercial Cable Co., New York, U. S. A. ..... Mar. 4, 1895
Edwards, Arthur M., M. D., F. L. S., Newark, N. J. .... Dec. 12, 1898
Haley, Prof. Frank R., Acadia College, Wolfville, N. S. .... Nov. 5, 1901
Harlow, L. C., B. SC., Prov. Normal School, Truro, N. S. .... Mar. 23, 1905
Haycock, Prof. Ernest, Acadia College, Wolfville, N. S. .... May 17, 1899
Jaggar, Miss A. Louise, Cambridge, Mass. .... Dec. 5, 1900
James, C. C., M. A., Deputy Min. of Agriculture, Toronto, Ontario ... Dec. 3, 1896
Jennison, W. F., Truro, N. S. .... May 5, 1903
*Johns, Thomas W., Yarmouth, N. S. .... Nov. 27, 1889
*Keating, E. H., C. E., Toronto, Ont.; Ordin. Memb., April 12, 1882.. Apr. 11, 1900
*MacKay, Hector H., M. D., New Glasgow, N. S. .... Feb. 4, 1902
Magee, W. H., PH. D., Annapolis, N. S. .... Nov. 29, 1894
Payzant, E. N., M. D., Wolfville, N. S. .... Apr. 8, 1902
Pineo, Avard V., LL. B., Kentville, N. S. .... Nov. 5, 1901
*Reid, A. P., M. D., L. R. C. S., Middleton, Annapolis, N. S. .... Jan. 31, 1890
*Robinson, C. B., PH. D., New York Botanical Garden, New York,
U. S. A. .... Dec. 3, 1902
*Rosborough, Rev. James, Musquodoboit Harbour, N. S. .... Nov. 29, 1894

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*Life Members.

CORRESPONDING MEMBERS.

	Date of Admission
Ami, Henry M., D. SC., F. G. S., F. R. S. C., Geological Survey, Ottawa Ontario	Jan. 2, 1892
Bailey, Prof. L. W., PH. D., LL. D., F. R. C. S., Fredericton, N. B.	Jan. 6, 1890
Ball, Rev. E. H., Tangier, N. S.	Nov. 29, 1871
Bethune, Rev. Charles J. S., M. A., D. C. L., F. R. S. C., Ontario Agricultural College, Guelph, Ont.	Dec. 29, 1868
Cox, Philip, B. SC., PH. D., Fredericton, N. B.	Dec. 3, 1902
Dobie, W. Henry, M. D., Chester, England	Dec. 3, 1897
Faribault. E. Rodolphe, B. A., B. SQ., Geological Survey of Canada, Ottawa; Assoc. Memb., March 6, 1888	Dec. 3, 1902
Ganong, Prof. W. F., B. A., PH. D., Smith College, Northampton, Mass., U. S. A.	Jan. 6, 1890
Hardy, Maj.-General Campbell, R. A., Dover, England. (Sole surviving Foundation Member; originally elected Dec. 26, 1862, and admitted Jan. 26, 1862.)	Oct. 30, 1903
Harrington, W. Hague, F. R. S. C., Post Office Department, Ottawa	May 5, 1896
Hay, George U., D. SC., F. R. S. C., St. John. N. B.	Dec. 3, 1902
Litton, Robert T., F. G. S., Melbourne, Australia	May 5, 1892
Matthew, G. F., M. A., D. SC., F. R. S. C., St. John, N. B.	Jan. 6, 1890
Maury, Rev. Mytton, D. D., Ithaca, N. Y., U. S. A.	Nov. 30, 1891
Mowbray, Louis L., Hamilton, Bermuda	May 3, 1907
Peter, Rev. Brother Junian	Dec. 12, 1898
Prest, Walter Henry, M. E., Bedford, N. S.; Assoc. Memb., Nov. 29, 1894	Nov. 2, 1900
Prichard, Arthur H. Cooper, Librarian, Numismatic Museum, New York, U. S. A.	Dec. 4, 1901
Prince, Prof. E. E., Commissioner and General Inspector of Fisheries, Ottawa, Ontario	Jan. 5, 189[illegible]

LIST OF PRESIDENTS

OF THE NOVA SCOTIAN INSTITUTE OF NATURAL SCIENCE, AFTERWARDS THE NOVA SCOTIAN INSTITUTE OF SCIENCE, SINCE ITS FOUNDATION IN 1862.

	Term of Office.
Hon. Philip Carteret Hill, D. C. L.	31 Dec. 1862 to 26 Oct. 1863
John Matthew Jones, F. L. S., F. R. S. C.	26 Oct. 1863 " 8 Oct. 1873
John Bernard Gilpin, M. A., M. D., M. R. C. S.	8 Oct. 1873 " 9 Oct. 1878
William Gossip	9 Oct. 1878 " 13 Oct. 1880
John Somers, M. D.	13 Oct. 1880 " 26 Oct. 1883
Robert Morrow	26 Oct. 1883 " 21 Oct. 1885
John Somers, M. D.	21 Oct. 1885 " 10 Oct. 1888
Prof. James Gordon MacGregor, M. A., D. SC., F.R.S., F.R.S.C.	10 Oct. 1888 " 9 Nov. 1891
Martin Murphy, C. E., D SC., I. S. O.	9 Nov. 1891 " 8 Nov. 1893
Prof. George Lawson, PH. D., LL. D., F. I. C., F. R. S. C.	8 Nov. 1893 " 10 Nov. 1895
Edwin Gilpin, Jr., M. A., LL. D., D. SC., F. G. S., F. R. S. C., I.S.O.	18 Nov. 1895 " 8 Nov. 1897
Alexander McKay M. A.	8 Nov. 1897 " 20 Nov. 1899
Alexander Howard MacKay, B. A., B. SC., LL. D., F. R. S. C.	20 Nov. 1899 " 24 Nov. 1902
Henry Skeffington Poole, M A., D. SC., A. R. S. M., F. G. S., F. R. S. C.	24 Nov. 1902 " 18 Oct. 1905
Francis William Whitney Doane, C. E.	18 Oct. 1905 " 11 Nov. 1907
Prof. Ebenezer Mackay, PH. D.	11 Nov. 1907 " 14 Nov. 1910

NOTE—Since 1879 the presidents of the Institute have been *ex-officio* Fellows of the Royal Microscopical Society.

The first general meeting of the Nova Scotian Institute of Natural Science was held at Halifax, on 31st December, 1862. On 24th March, 1890, the name of the society was changed to the Nova Scotian Institute of Science, and it was incorporated by an act of the legislature in the same year.

The oundation of the Halifax Mechanics' Institute on 27th December, 1831, and of the Nova Scotian Literary and Scientific Society about 1859 (the latter published its Transactions from 4th January to 3rd December, 1859) had led up to the establishment of the N. S. Institute of Natural Science in December, 1862.

XIII

APPENDIX IV

LIST OF MEMBERS 1909-10

ORDINARY MEMBERS

Date of Admission

Bancroft, George R., Academy, Halifax.........................Jan. 7, 1908
Barnes, Albert Johnson, B. SC., service inspector Maritime Telephone & Telegraph Co., Halifax.............................May 13, 1912
Bishop, Watson L., Supt. Waterworks, Dartmouth, N. S.......... Jan. 6, 1890
Bowman, Maynard. B. A., Public Analyst, Halifax ....Mar. 13, 1884
Bronson, Prof. Howard Logan, PH. D., Dalhousie College, Halifax ..Mar. 9, 1911
Brown, Richard H., Halifax ....Feb. 2, 1903
Budge, Daniel, General Supt. Halifax & Bermuda Cable Co., Halifax..Oct. 30, 1903
*Campbell, Donald A., M. D., Halifax..........................Jan. 31, 1890
Campbell, George Murray, M. D., Halifax ....Nov. 10, 1884
Colpitt, Parker R., City Electrician, Halifax ....Feb. 2, 190?
Creighton, Henry Jermain Maude, M. A., M. SC., DR. SC., F. C. S., Dalhousie College, Halifax ....Jan. 7, 1908
*Davis, Charles Henry, C. E., New York City, U. S. A. ....Dec. 5, 1900
Davis, Harold, S., B. A., Dalhousie College, Halifax.. ....Mar. 9, 1911
Doane, Francis William Whitney, City Engineer, Halifax ....Nov. 3, 1886
Donkin, Hiram, M. E., Deputy Com. of Mines, Halifax ....Nov. 30, 1892
Fergusson, Donald M., chemist, Acadia Sugar Ref. Co., Halifax ....Jan. 5, 1909
*Forbes, John, Halifax .... Mar. 14, 1883
*Fraser, C. Frederick, LL. D., Principal, School for the Blind, Halifax..Mar. 31, 1890
Freeman, Philip A., Hx. Elect. Tramway Co., Halifax ....Nov. 6, 1906
Harlow, A. C., Montreal ....Jan. 7, 1908
Harris, Prof. David Fraser, M. D., D. SC., F. R. S. E., Dalhousie College, Halifax.......................................Feb. 29, 1912
Hattie William Harrop, M. D., Supt. N. S. Hospital, Dartmouth. ...Nov. 12, 1892
Hayward, A. A., Halifax ....Nov. 7, 1905
Howe, Prof. Clarence D., B. SC., Dalhousie College, Halifax.......Mar. 9, 1911
Irving, G. W. T., Education Dept., Halifax ....Jan. 4, 1892
Johnston, Harry W., C. E., Asst. City Engineer, Halifax ....Dec. 31, 1894
Kelly, Rev. M. C., St. Mary's College, Halifax.. ....Jan. 4, 1910
*Laing, Rev. Robert, Halifax ....Jan. 11, 1885
McCallum, A. L., B. SC., analyst, Halifax.........................Jan. 7, 1908
McCarthy, Prof. J. B., B. A., M. SC., King's College, Windsor, N. S.. Dec. 4, 1901
McColl, Roderick, C. E., Provincial Engineer, Halifax..............Jan. 4, 1892
*MacGregor, Prof. James Gordon, M. A., D. SC., F. R. S., F. R. S. C., Edinburgh University, Edinburgh, Scotland ....Jan. 11, 1877
McInnes, Hector, LL. B., Halifax ....Nov. 27, 1889
MacIntosh, Donald Sutherland, B. A., M. SC., Dalhousie Col., Halifax ..Mar. 9, 1911
*McKay, Alexander, M. A., Supervisor of Schools, Halifax.......... Feb. 5, 1872
*MacKay, Alexander Howard, B. A., B. SC., LL. D., F. R. S. C., Superintendent of Education, Halifax ....Oct. 11, 1885
Mackay, Prof. Ebenezer, PH. D., Dalhousie College, Halifax ....Nov. 27, 1889
*MacKay, George M. Johnstone, Schenectady, N. Y., U. S. A.. .....Dec. 18, 1903
MacKenzie, Prof. Arthur Stanley, PH. D., Dalhousie College, Halifax .Nov. 7, 1905
McKerron, William, Halifax ....Nov. 30, 1891
McLearn, F. H., B. A. ....Oct. 14, 1908
McNeill, Prof. Murray, Dalhousie College.......................Jan. 7, 1908

*Life Members.

	Date of Admission
Marshall, Guilford R., B. A., Halifax	Apr. 4, 1894
Moore, Prof. Clarence L., M. A., Dalhousie College, Halifax	Jan. 7, 1908
Morton, S. A., M. A., County Academy, Halifax	Jan. 27, 1893
Murray, Prof. Daniel Alexander, PH. D., Montreal	Dec. 18, 1903
Nickerson, Carleton Bell, M. A., Dalhousie College, Halifax	Mar. 9, 1911
Pickings, H. B., Mines Department, Halifax	May 6, 1908
Piers, Harry, Curator Provincial Museum and Librarian Provincial Science Library, Halifax	Nov. 2. 1888
*Poole, Henry Skeffington, A. M. ASSOC. R. S. M., F. G. S., F. R. S. C., CAN. SOC. C. E., HON MEM. INST. M. E., Guildford, Surrey, England	Nov. 11, 1872
*Robb, D. W., Amherst, N. S.	Mar. 4, 1890
Robinson, Ernest, B. A., Canning, N. S.	Jan. 7, 1908
Rutherford, John, M. E., Halifax	Jan. 8, 1865
Sexton, Prof. Frederic H., Director of Technical Education, Halifax.	Dec. 18, 1903
*Smith, Prof. H. W., B. SC., Agricultural College, Truro, N. S.; Assoc. Memb., Jan. 6, 1890	Dec. 1900
Stapleton, W. C., B. A., Supervisor of Schools, Dartmouth, N. S.	Oct. 14, 1908
*Stewart, John, M. B. C. M., Halifax	Jan. 12, 1885
Wilson, Robert J., Secretary, School Board, Halifax	May 3, 1889
Winfield, James H., Manager, N. S. Telephone Co., Halifax	Dec. 18, 1903
Woodman, Prof. J. Edmund, M. A., D. SC., New York University, New York, U. S. A.	Dec. 3, 1902
*Yorston, W. G., C. E., City Engineer, Sydney, C. B.	Nov. 12, 1892

ASSOCIATE MEMBERS

Brodie, W. S., B. A., Lunenburg, N. S.	May 7, 1909
*Caie, Robert, Yarmouth, N. S.	Jan. 31, 1890
Connolly, Prof. J. C., PH. D., St. Francis Xavier, Antigonish, N. S.	Nov. 5, 1911
Edwards, Arthur M., M. D., F. L. S., Newark, N. J.	Dec. 12, 1898
Haley, Prof. Frank R., Acadia College, Wolfville, N. S.	Nov. 5, 1901
Harlow, L. C., B. SC., Prov. Normal School, Truro, N. S.	Mar. 23, 1905
Haycock, Prof. Ernest, Acadia College, Wolfville, N. S.	May 17, 1899
James, C. C., M. A., Deputy Min. of Agriculture, Toronto, Ontario	Dec. 3, 1896
Jennison, W. F., Truro, N. S.	May 5, 1903
*Johns, Thomas W., Yarmouth, N. S.	Nov. 27, 1889
*MacKay, Hector H., M. D., New Glasgow, N. S.	Feb. 4, 1902
Magee, W. H., PH. D., Annapolis, N. S.	Nov. 29, 1894
Payzant, E. N., M. D., Wolfville, N. S.	Apr. 8, 1902
Pineo, Avard V., LL. B., Kentville, N. S.	Nov. 5, 1901
*Reid, A. P., M. D., L. R. C. S., Middleton, Annapolis, N. S.	Jan. 31, 1890
*Robinson, C. B., PH. D., New York Botanical Garden, New York, U. S. A.	Dec. 3, 1902
*Rosborough, Rev. James, Musquodoboit Harbour, N. S.	Nov. 29, 1894

*Life Members.

CORRESPONDING MEMBERS

	Date of Admission
Ami, Henry M., D. SC., F. G. S., F. R. S. C., Geological Survey, Ottawa Ontario	Jan. 2, 1892
Bailey, Prof. L. W., PH. D., LL. D., F. R. C. S., Fredericton, N. B.	Jan. 6, 1890
Ball, Rev. E. H., Tangier, N. S.	Nov. 29, 1871
Barbour, Capt. J. H., R. A. M. C., F. L. S., Nowgong, Bundelkhand, Central India.	Dec. 28, 1911
Bethune, Rev. Charles J. S., M. A., D. C. L., F. R. S. C., Ontario Agricultural College, Guelph, Ont.	Dec. 29, 1868
Cox, Philip, B. SC., PH. D., Fredericton, N. B.	Dec. 3, 1902
Dobie, W. Henry, M. D., Chester, England	Dec. 3, 1897
Faribault, E. Rodolphe, B. A., B. SC., Geological Survey of Canada, Ottawa; Assoc. Memb., March 6, 1888	Dec. 3, 1902
Ganong, Prof. W. F., B. A., PH. D., Smith College, Northampton, Mass., U. S. A.	Jan. 6, 1890
Hardy, Maj.-General Campbell, R. A., Dover, England. (Sole surviving Foundation Member; originally elected Dec. 26, 1 3 2 and admitted Jan. 26, 1862.)	Oct. 30, 1903
Harrington, W. Hague, F. R. S. C., Post Office Department, Ottawa	May 5, 1896
Hay, George U., D. SC., F. R. S. C., St. John, N. B.	Dec. 3, 1902
Litton, Robert T., F. G. S., Melbourne, Australia	May 5, 1892
Matthew, G. F., M. A., D. SC., LL. D., F. R. S. C., St. John, N. B.	Jan. 6, 1890
Maury, Rev. Mytton, D. D., Ithaca, N. Y., U. S. A.	Nov. 30, 1891
Mowbray, Louis L., Hamilton, Bermuda	May 3, 1907
Peter, Rev. Brother Junian	Dec. 12, 1898
Prest, Walter Henry, M. E., Bedford, N. S.; Assoc. Memb., Nov. 29, 1894	Nov. 2, 1900
Prichard, Arthur H. Cooper, Librarian, Numismatic Museum, New York, U. S. A.	Dec. 4, 1901
Prince, Prof. E. E., Commissioner and General Inspector of Fisheries, Ottawa, Ontario.	Jan. 5, 1897

LIST OF PRESIDENTS

OF THE NOVA SCOTIAN INSTITUTE OF NATURAL SCIENCE, AFTERWARDS THE NOVA SCOTIAN INSTITUTE OF SCIENCE, SINCE ITS FOUNDATION ON 31ST DECEMBER, 1862.

	Term of Office.		
Hon. Philip Carteret Hill, D. C. L.	31 Dec. 1862	to	26 Oct. 1863
John Matthew Jones, F. L. S., F. R. S. C.	26 Oct. 1863	"	8 Oct. 1873
John Bernard Gilpin, M. A., M. D., M. R. C. S.	8 Oct. 1873	"	9 Oct. 1878
William Gossip	9 Oct. 1878	"	13 Oct. 1880
John Somers, M. D.	13 Oct. 1880	"	26 Oct. 1883
Robert Morrow	26 Oct. 1883	"	21 Oct. 1885
John Somers, M. D.	21 Oct. 1885	"	10 Oct. 1888
Prof. James Gordon MacGregor, M. A., D. SC., F.R.S.. F.R.S.C.	10 Oct. 1888	"	9 Nov. 1891
Martin Murphy, C. E., D. SC., I. S. O.	9 Nov. 1891	"	8 Nov. 1893
Prof. George Lawson, PH. D., LL. D.. F. I. C., F. R. S. C.	8 Nov. 1893	"	10 Nov. 1891
Edwin Gilpin, Jr., M. A., LL. D., D. SC., F. G. S., F. R. S. C., I.S.O.	18 Nov. 1895	"	8 Nov. 1893
Alexander McKay M. A.	8 Nov. 1897	"	20 Nov. 1895
Alexander Howard MacKay, B. A.. B. SC., LL. D., F. R. S. C.	20 Nov. 1899	"	24 Nov. 1907
Henry Skeffington Poole, M A., D. SC., A. R. S. M., F. G. S., F. R. S. C.	24 Nov. 1902	"	18 Oct. 1905
Francis William Whitney Doane, C. E.	18 Oct. 1905	"	11 Nov. 1907
Prof. Ebenezer Mackay, PH. D.	11 Nov. 1907	"	12 Dec. 1910
Watson L. Bishop	12 Dec. 1910	"	———

NOTE—Since 1879 the presidents of the Institute have been *ex-officio* Fellows of the Royal Microscopical Society.

The first general meeting of the Nova Scotian Institute of Natural Science was held at Halifax, on 31st December, 1862. On 24th March, 1890, the name of the society was changed to the Nova Scotian Institute of Science, and it was incorporated by an act of the legislature in the same year.

The foundation of the Halifax Mechanics' Institute on 27th December, 1831, and of the Nova Scotian Literary and Scientific Society about 1859 (the latter published its Transactions from 4th January to 3rd December, 1859) had led up to the establishment of the N. S. Institute of Natural Science in December, 1862.

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